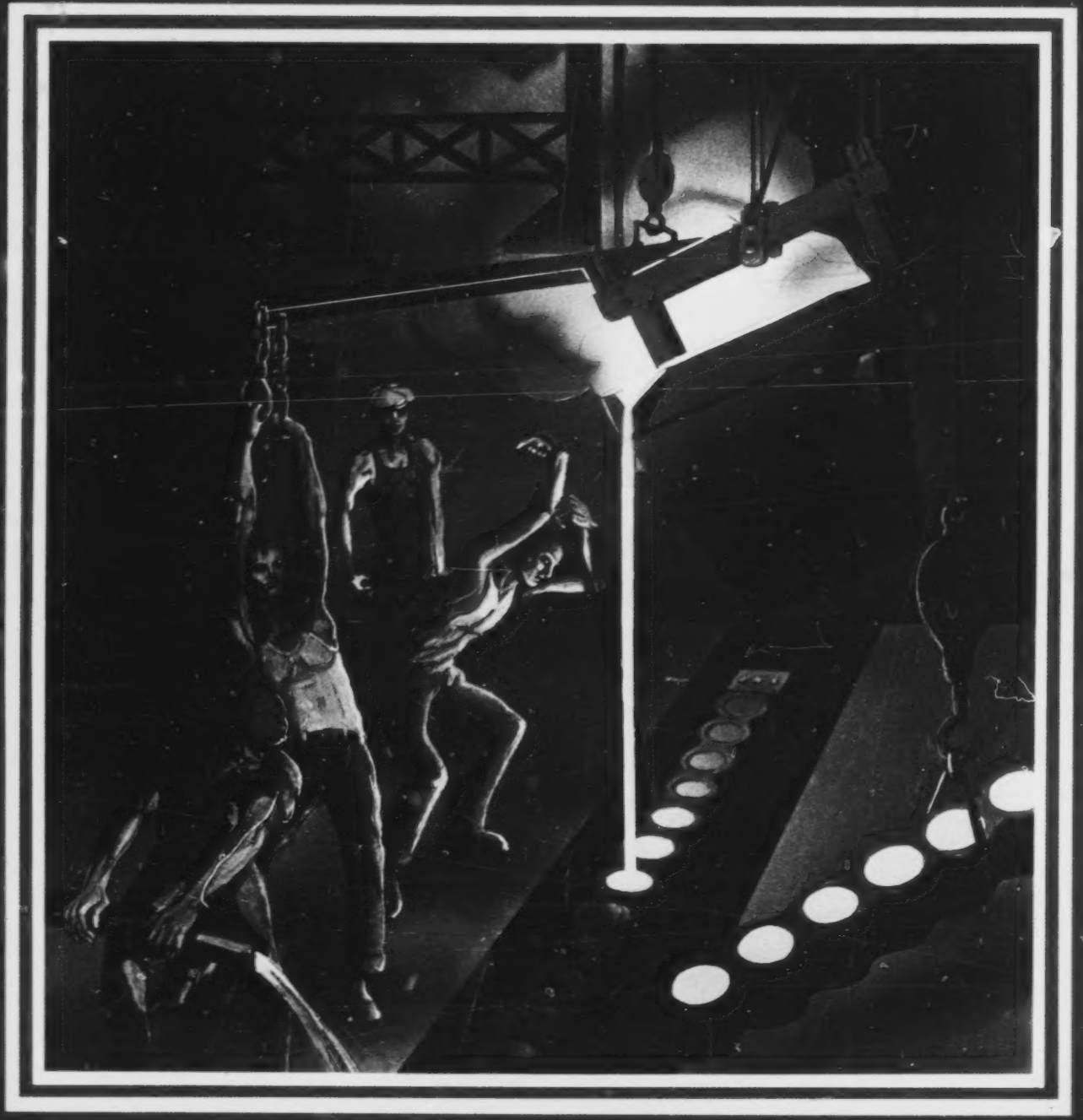
Electric Perspectives



Neoindustrialization

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Contents

Features

3 Neoindustrialization: The Resource Impetus

Because our resource base is changing, industry may have to adopt new production technologies in order to boost productivity
By Mary H. Wayne

9 TMI-2: Making Strides in Research and Recovery

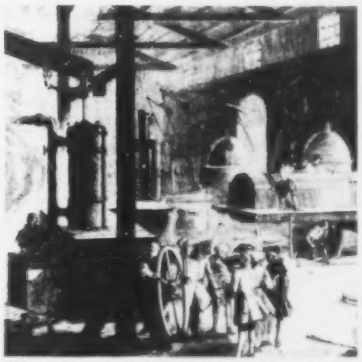
Government and industry research at Three Mile Island is a driving force behind efforts to recover the plant
By Marie Mastin Newman

17 The Power of Energy Education

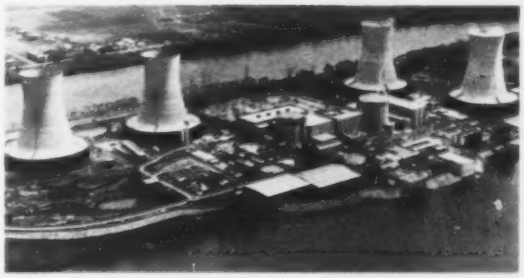
The Energy Source Program will give students across the country a lifelong awareness of energy issues
By Ernest Roberson and Fred C. Neidermeyer with Kathy Renner

23 The Wrong Answers to the Right Questions

Journalists are misinforming the public about the scientific community's assessment of radiation's health effects
By Bernard L. Cohen



Page 3 THE BETTMANN ARCHIVE, INC.



Page 9

Reviews

27 Financial Review

30 Book Review

40 Statistical Review

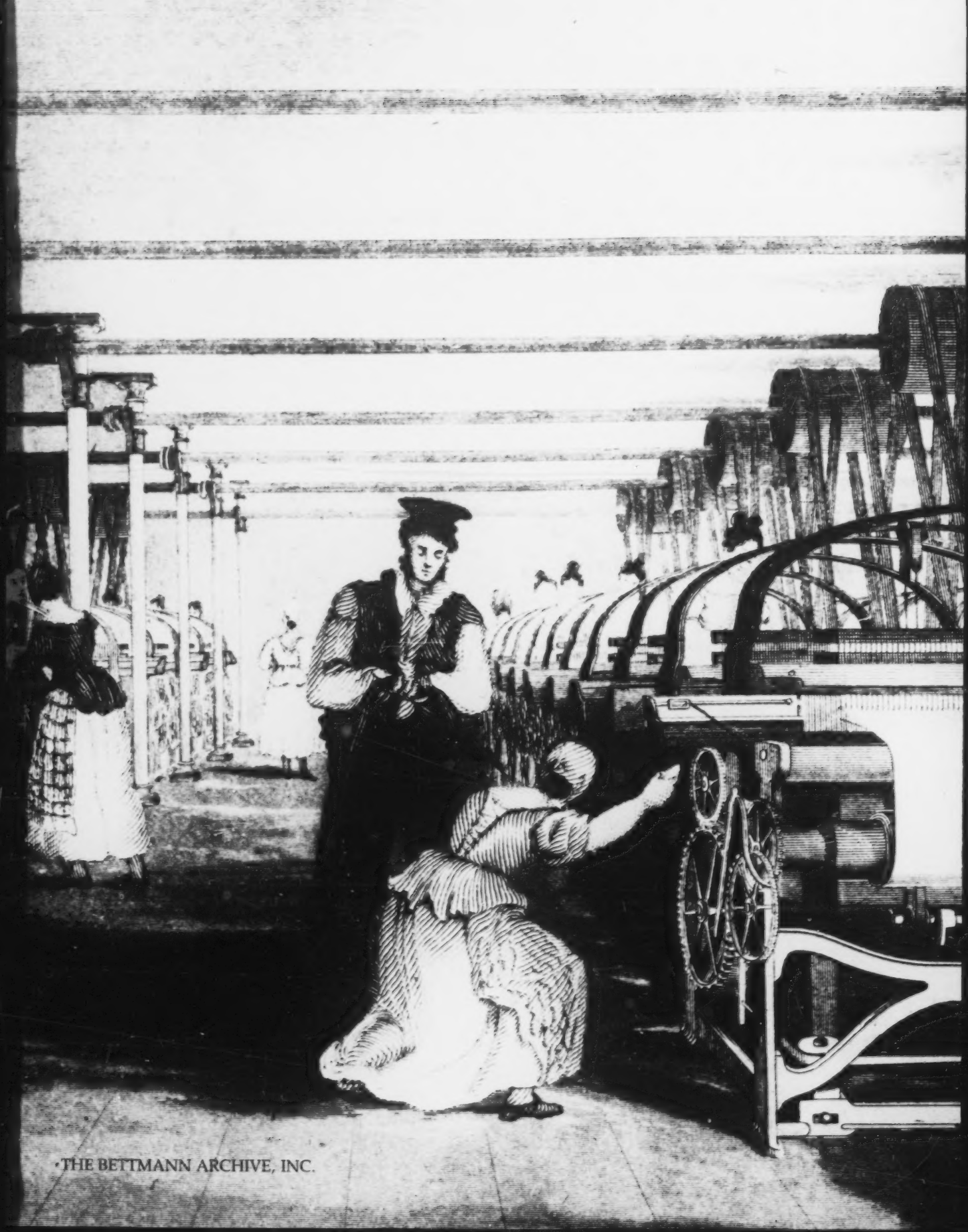
42 Regulatory Review

48 Technology Review

Page 17

Cover: The electric arc furnace and induction heating may revolutionize the steel industry—represented here as it was in the 1920s—just as coal-fired furnaces revolutionized the iron industry 300 years ago.

Illustration by Michael J. McGurk



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Neoindustrialization: The Resource Impetus

By Mary H. Wayne

Because our resource base is changing, industry may have to adopt new production technologies in order to boost productivity

Resources and Technologies. How do they affect our economic productivity? In this three-part series, author Mary Wayne shows how the match between the raw materials and the production methods industry uses to produce goods is a critical determinant of productivity. Part 1 reviews how a shift in that match gave rise to the industrial revolution and why the U.S. economy may be on the verge of a similar shift. The second part of the series will examine the role innovation plays in sharpening the match between raw materials and production methods and will highlight some of the new technologies that may be ushering in a second revolution—one in which industry becomes more productive through the increased use of electricity. Part three will consider some of the broader social implications of these changes, which are referred to collectively as the process of "neoindustrialization."

Human labor has its limits. Productivity, defined as output per hour of work, depends heavily on the use of machinery. Without machinery or a power source to drive it, low productivity is the rule. Yet the kind of productivity that we now take for granted in industrialized nations is relatively recent in human history.

Until the eighteenth century, the major supplements to human muscle power were the muscles of domesticated animals, mainly horses and oxen. Wind power was used mostly for sailing ships. Only the power of falling water gave a hint of things to come.

Harnessing the flow of England's streams and rivers with simple water mills, textile makers in the early 1700s took the lead in applying the concept of power machinery to producing goods. In 1718, a silk-spinning operation using water power opened in Derby. Soon a spate of new inventions such as John Kay's flying shuttle (1733), James Hargreaves' spinning jenny (1767), and Richard Arkwright's water frame (1770) had spinners producing yarn faster than the weavers could turn it into cloth. In 1785, Edmund Cartwright allowed the weavers to catch up by creating the power loom, a machine that could weave automatically and so multiply each worker's output by allowing one worker to tend two or three looms at a time.

But this was only the beginning. Manufacturing that relied on water power could take place only at sites near a suitable water source. And the number of sites was limited—too limited to support the transformation that was about to take place. The idea of using power machinery to produce goods had taken hold, but a versatile power source was lacking.

Meanwhile, developments were occurring that would provide that power source. Wood, England's traditional fuel, was growing scarce. The heavy demand for wood to provide charcoal for smelting metal ore had severely depleted England's forests. This highly wasteful use of wood in an inefficient smelting process had left the British with their own eighteenth-century energy crisis.

Fortunately, the wood shortage opened the door to use of a new industrial energy resource: coal. England had plenty of coal. But coal combustion produced fumes that could damage the materials being processed, so switching from wood to coal meant a rethinking of many existing procedures. The result was a chain reaction of new inventions that would go far beyond water-driven machinery in the type

Fortunately, the wood shortage opened the door to use of a new industrial energy resource: coal.

Mary H. Wayne is a free-lance writer based in San Francisco who specializes in energy issues.

and volume of goods that could be produced. According to science historian John U. Nef, "The adoption of coal changed the economic history of Britain . . . and finally of the world. It led to the Industrial Revolution."[1]

The great transformation in methods of production that commonly is known as the Industrial Revolution began in England at the dawn of the eighteenth century. In fact, 1709 is the year in which Abraham Darby first discovered a method for smelting iron with coal and lime instead of wood, although a cheap and rapid version of Darby's method was not perfected until later in the century.

By the 1820s, coal-fired steam power had replaced water power even in its home, the textile industry.

This smelting innovation in turn allowed large-scale casting of iron parts that would be used to construct a host of new machines. Further, coal's role extended beyond smelting the metal that would build the engines of the revolution. Burning coal would also provide the power to drive them, by applying the concentrated heat energy locked within each lump to the production of steam.

Experiments with steam power predate the Christian era. In the second century B.C., Hero of Alexandria mused on the motive force of expanding steam, writing of a "rotary engine driven by the reaction of steam issuing from the orifices in revolving arms."[2] By the sixteenth century A.D., Leonardo da Vinci was designing steam-driven catapults as war machines. But it was not until Englishman Thomas Newcomen built the first modern steam engine in 1712, with cylinder and piston, that the potential for steam power approached practical reality. James Watt's improvements on the Newcomen engine, which were patented in 1769, produced a coal-burning engine that was ready to take on much of the heavy work of Britain's evolving industries.

Appropriately enough, one of the first applications of the new steam engine was to pump out the groundwater that was threatening to inundate the nation's coal mines. Gaining mechanical help with this heavy labor made it go much faster, and mining productivity soared. What's more, using steam engines in coal mines helped to accelerate the process of industrialization that already was taking place. Boosting coal production made yet more fuel available to smelt the iron that would build yet more machines.

In 1793, a French coal mine used a steam engine working only 48 hours per week to pump water that had formerly taken 50 men and 20 horses working around the clock to remove. By 1800, some 500 Watt steam engines were in service, about 40 percent for pumping water and 60 percent for the generation of mechanical power in industry.[3]

As early as 1824, Frenchman Sadi Carnot, father of modern thermodynamics, recognized the tremendous impact the steam engine would have on England's economy: "Already the heat engine works our mines, propels our ships, deepens our harbors and rivers, forges iron, fashions wood, grinds our corn, spins and weaves our fabrics, pulls the heaviest loads, etc. It seems as though one day it will be the general motive power which will overpass animal power, waterfalls, and wind currents. It has the advantage over the first mentioned motor-power of cheapness and the inestimable advantage as against the others of being always and everywhere applicable and never ceasing work.

"For it will not only be possible to replace the motive powers now used by a more powerful and convenient motive power which can be obtained and conveyed everywhere; but it will create a rapid development in the industries in which it is used—indeed it may well establish new industries.

"Iron and fire are recognized as the sustenance and support of mechanical industry. Perhaps there is no single factory in England whose existence is not founded on the use of these elements and in which they are not abundantly applied. If England today were to be deprived of her steam engines, she would also be robbed of coal and iron; all her sources of wealth would be cut off and all her means of development would be destroyed; this would mean the ruin of this vast Power. The destruction of her fleet, which is regarded as her most certain protection, would perhaps be less fatal for England."[4]

By the 1820s, coal-fired steam power had replaced water power even in its home, the textile industry. The in-

creases in productivity were staggering. Whereas the introduction of water-powered machinery had doubled or tripled the output capacity of each worker, steam-driven machines multiplied that advantage many times over.

"A cotton-spinning establishment offers a remarkable example of how, by the use of very great power, an enormous quantity of the easiest work can be accomplished," wrote an English observer in 1835. "Often we may see in a single building a 100 horse-power steam engine, which has the strength of 880 men, set in motion 50,000 spindles besides all the auxiliary machines. The whole requires the service of only 750 workers. But these machines, with the assistance of that mighty power, can produce as much yarn as formerly could hardly have been spun by 200,000 men, so that one man can now produce as much as formerly required 266!"[5]

So the transition known as the Industrial Revolution, which in reality unfolded slowly and gradually throughout the 1700s and the first half of the 1800s, released labor's productive power from the physical constraints of the human body. Steam technology, resting firmly on a resource base of coal and iron, multiplied man's efforts. For the first time, machines took over some of society's heaviest jobs, accomplishing them with less effort and greater efficiency than hitherto imagined.

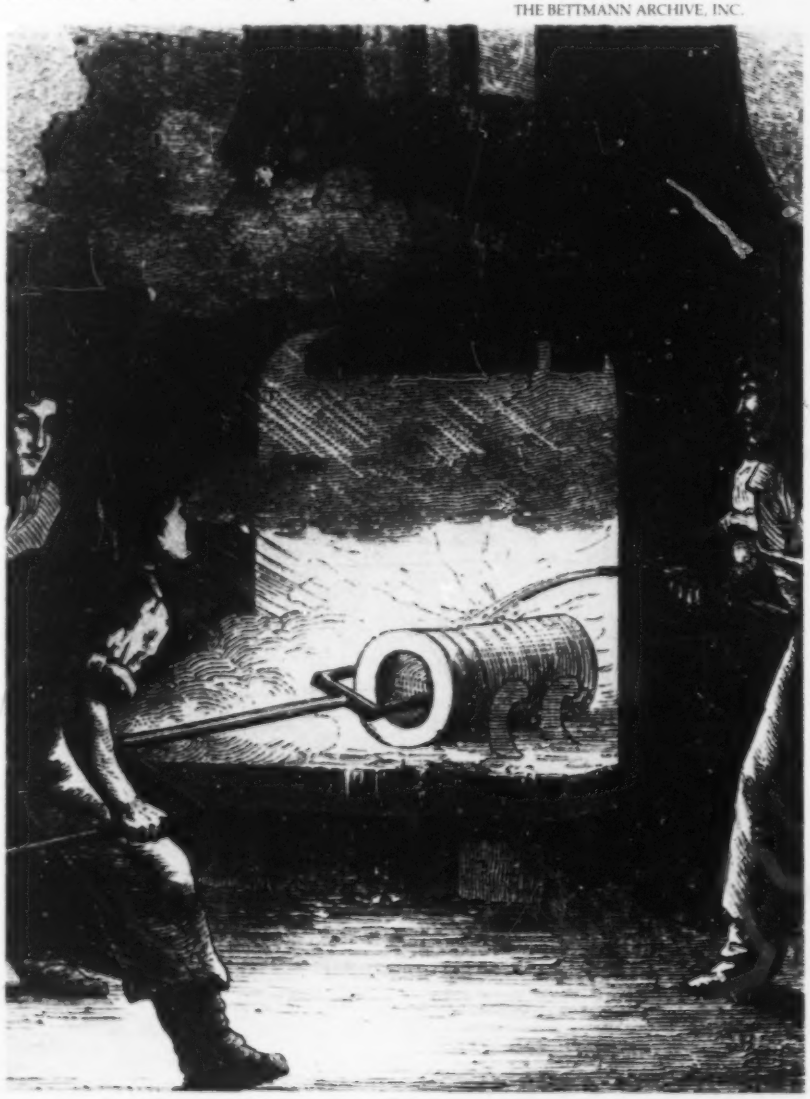
Resource Depletion: A Modern Parallel

Moving ahead now more than a century, we find industrialization an accomplished fact. But again, a changing resource base is forcing us to take a fresh look at our methods of production.

Oil and gas, which have largely replaced coal for industrial combustion because they are cleaner and more convenient to use, are now themselves in question. Just as wood depletion threatened metals production in eighteenth-century England, oil and gas depletion now threatens a wide range of current production methods. This depletion is manifest in supply shortages and rising prices.

As long as oil and gas were cheap, it was easy to stick to established technologies, even if they required lavish fuel use. Abundant, inexpensive fuel kept industry's machines humming and productivity rising. But when supply crunches and higher prices caused fuel cutbacks, the machinery began to slow and industrial production began to sag.

Productivity gains in the United States for private business, including manufacturing, grew at a rate of 3.2 percent annually during the years after World War II, slowing somewhat to a 2.4 percent rate in the mid-sixties. Beginning in 1973, however, the first year of the Arab oil embargo, there was a sharp decline. The period 1973–1979 averaged an anemic 0.8 percent annual productivity gain. And the early eighties have been marked by a seesaw pat-



Factory workers shape an iron pipe with a steam hammer, circa 1860.

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tern of alternating gains and losses as the economy in general, and the manufacturing sector in particular, have tried to reestablish their momentum.

Recognition has grown that the changes in our resource base are not temporary, but permanent. We are consuming finite resources that will grow increasingly scarce and costly over time, despite occasional periods of relief such as those marked by the "gas bubble" and the "oil glut." Technical consultant Charles A. Berg has developed an analysis with figures that illustrate the direction of this growing resource bind.[6]

Over the past decade, the average cost of all industrial raw materials has climbed steadily at an annual rate of about 8 percent.

The rise in energy costs is well documented. Oil prices, for example, increased about twentyfold during the seventies. In 1970, producing a ton of glass containers took only $2.40 worth of oil. Today, despite glass manufacturers' best efforts at reducing the fuel requirements of present glass-making technology, it takes about $40 worth of oil to produce the same amount of glass. The actual amount of fuel used is somewhat less, as much as 20 percent less in the most efficient plants, but costs per unit of fuel have risen so dramatically that even vigorous conservation has made only a small dent in industry's inflated fuel bill.

Indirect effects of the fuel cost squeeze are also substantial. Despite better process efficiency, oil costs to reheat a ton of steel in a conventional furnace prior to rolling or forging have risen from about $2.90 in 1970 to $12–$14 today, according to Berg. They have more than quadrupled. So production costs are higher not only for the steel manufacturers, but also for all those industries that use steel in creating their own finished products—everything from airplanes and autos to knives and forks.

Peripheral costs are up too. Transportation, warehousing, and distribution of products are higher due to increases in gasoline and heating oil prices. And workers themselves have felt the pinch: the escalating costs of commuting and home heating have been reflected in the spiraling wage demands of the late 1970s, bringing further pressure to bear on the total costs of producing the nation's goods.

Beyond the ripples of the fuel-cost explosion, there is another issue regarding our resource base that is less familiar but just as significant. That issue is the cost and availability of raw materials.

Over the past decade, the average cost of all industrial raw materials has climbed steadily at an annual rate of about 8 percent. More dramatic is the sharp price increase among precisely those resources that are most critical to heavy industry. For example, the production of many high-performance metals depends on the use of chromium, nickel, molybdenum, manganese, or cobalt ores. Since 1970, according to Berg, chromium, nickel, and manganese have more than doubled in price; molybdenum has quintupled; and cobalt now costs about 11 times what it did at the beginning of the seventies.

Furthermore, ownership and control of these strategic mineral resources are largely in foreign hands, a situation analogous to the familiar oil supply dilemma. Four countries—the Philippines, Zimbabwe, the Republic of South Africa, and Turkey—produce about half of all the world's chromium. Another quarter comes from communist bloc nations. And 99 percent of the world's reserves rest in politically turbulent South Africa.

The United States, meanwhile, is using more chromium than ever before to feed metals production. Chromium consumption has grown nearly 50 percent since 1975. Domestic reserves, which represent only about 10–12 years supply, reside in very low-grade ores and are clearly inadequate to sustain healthy high-performance metals production in the event of a foreign supply cutoff. Except for molybdenum, which the United States possesses in abundance, the situation is similar with other strategic minerals.

Berg estimates that about 36 percent of the world's nickel comes from four countries: Canada (17 percent) New Caledonia (11 percent), Cuba (6 percent), and the United States (2 percent). The United States currently consumes some 271,000 tons of nickel per year, with consumption growing at an annual average rate of roughly 6.5 percent since 1975. About 77 percent of this nickel is imported. Domestic reserves of nickel represent approximately 10

years' supply at present rates of consumption.

Manganese plays an essential part in the primary chemistry of iron-making and is used in nearly all ferrous alloys, as Berg points out. It also is required in batteries and in certain electrochemical processes. The United States now consumes about 1,300,000 tons of manganese per year and depends on imports to supply 98 percent of it. South Africa (21 percent,), Gabon (8 percent), India (8 percent), Australia (6 percent), and Brazil (5 percent) are the world's leading producers.

Cobalt is necessary in metals production for high-temperature operations such as forging dies. It is also essential in making the newly developed powdered nonferrous alloys that can be used for direct forming of critical aircraft engine parts. Berg estimates that domestic consumption now runs about 18,000 tons per year, up sharply from the 1970 level of 13,000 tons. Most of this cobalt is imported from the 5 countries that produce the lion's share: Zaire (41 percent), New Caledonia (13 percent), Australia (11 percent), Zambia (8 percent), and Morocco (6 percent).

These strategic materials are not the only ones of concern to industry, says Berg, but the supply and price situations are typical. During the late seventies, the price of cobalt, for example, rose even faster than the then-skyrocketing price of gold.

These minerals, like oil and gas, are indispensable to our present methods of industrial production. And ironically, the oil crisis has contributed to a minerals crisis by boosting the demand for them: the deep-drilling equipment required for much new oil exploration is produced with these minerals, and the same is true of the conservation equipment now installed in industrial plants to curb oil consumption. In Berg's words, "All attempts to modify the conventional techniques of production to reduce fuel consumption appear to accelerate the growth of demand for critical minerals."[7]

Escaping the Bind

Given the dwindling state of the resource base upon which our current methods of production reside, it makes no sense to save scarce and costly fuels by substituting scarce and costly minerals. Berg proposes that what is required by this change in the resource base are entirely new methods of production, methods that rely on different power sources and utilize different raw materials in new ways.

Historical precedents abound. For instance, Arkwright's invention of the water-driven spinning frame back in 1770 allowed both the exploitation of cheap and abundant cotton fibers and the substitution of water power for human muscle power. Prior to this invention, British industry had been unable to produce pure cotton threads that were strong enough to be used for the warp in woven fabric. The new all-cotton product replaced the more expensive half-linen yarn formerly used, triggering rapid expansion in the manufacture of affordable cotton clothing.

. . . it makes no sense to save scarce and costly fuels by substituting scarce and costly minerals.

Another example that Berg cites to show how a new technology can increase access to existing resources is the Hall-Heroult process for reducing aluminum. Before this process was introduced in 1886, aluminum was so difficult to extract from ore that it had the status of a highly precious metal. It cost $575 per pound and was used in preference to gold, which was cheaper, in making spoons for the table of Napoleon III. By the early 1900s, the price of aluminum, by then easily produced, had fallen to $0.30 per pound and was beginning to replace steel in lightweight fabrications.

The reverse can occur as a material grows scarcer or less accessible. In the future, Berg speculates, "the fact that oil and gas are combustible may be no more important . . . than the fact that veneer logs or rosewood are also combustible. Oil and gas will probably have to be used with greater economy, and with greater attention to exploiting their distinctive physical characteristics, particularly their high concentration of hydrogen. Oil and gas may ultimately come to be used exclusively for light liquid fuels and chemical feedstocks."[8]

In their place, the emphasis will fall on cheap and abundant domestic fuel resources. Domestic coal, uranium, and solar resources of all kinds converted into electricity may provide an increasing share of the power needed to run industry's machines. And in

fact, the benefits of some electrically-based technologies already go far beyond their ability to use domestic fuels: they are also faster, cheaper, and generally more productive than their conventional steam-based counterparts.[9]

As for different raw materials, Berg suggests that light nonferrous metals may substitute well for ferrous alloys in many applications. The additional elements required in structural grade aluminum, titanium, and magnesium alloys, for instance, are more abundant and far less concentrated than those required for high-quality ferrous alloys. What's more, the light nonferrous metals are easily and cheaply recycled. Another possibility for raw materials substitution may be the development of new techniques that can use wood and other plant matter instead of oil in chemical feedstock applications. The ratio of hydrogen to carbon is nearly as high in such materials as it is in fossil hydrocarbons.

"To transform the use of natural resources implies a fundamental transformation of the techniques of production themselves."

These are only a few of the possibilities. The point is not to detail the many ways in which new technologies can utilize different resources, but simply to recognize that such alternatives do exist. Some are still experimental, whereas others are already operating on a limited scale.

Multiple factors affect industrial productivity. Some of them have nothing to do with technology or the resource base. Nevertheless, the ability to produce is clearly tied to the prevailing level of technology, and technologies in turn are firmly grounded in the use of certain fuels and raw materials that the resource base provides.

"All methods of production are strongly shaped, at their conceptual foundations, by the physical character of the natural resources upon which they draw. To transform the use of natural resources implies a fundamental transformation of the techniques of production themselves," comments Berg.[10]

While some new methods adopted out of necessity may fall short of the old ones in productive capacity or simply maintain prior levels of productivity, others may bring dramatic increases in the level of goods and services that an economy can provide. Historically, the tendency has been for new methods to improve productivity. This was surely the case during the eighteenth and nineteenth centuries, when coal largely replaced muscle, wind, water, and wood as the motive force in industry. The result was the development of coal-based steam technologies that indeed revolutionized industry's ability to produce.

Just such a change may once again be imminent, given the shifts in our available resource base. The stage is set. Our resource bind creates the need. Abundant though previously neglected domestic resources offer the means. And the technology to implement new and more efficient production methods is already at hand. All that is lacking is sufficient awareness of the opportunity that these new methods represent.

Notes

1. John U. Nef, "An Early Energy Crisis and Its Consequences," *Scientific American*, Nov. 1977, p. 141.
2. Hero of Alexandria, *Pneumatics*, as quoted by Robert Ergang in *Europe: From the Renaissance to Waterloo*, 3rd ed., (Boston: D.C. Health, 1967), p. 561.
3. Philip S. Schmidt, "Everything You Always Wanted to Know About Steam," unpublished manuscript, pp. 4,6.
4. Sadi Carnot, as quoted by Friedrich Klemm in *A History of Water Technology* (Cambridge: MIT Press, 1964), p. 275-76.
5. Edward Baines, as quoted by Friedrich Klemm in *A History of Water Technology* (Cambridge: MIT Press, 1964), p. 290.
6. Charles A. Berg, "Dealing with Inflation: The Role of Electricity," unpublished report prepared for Edison Electric Institute.
7. See Berg, p. 30.
8. See Berg, p. 34.
9. Mary H. Wayne, "Electrotechnology: Sparking Productivity in Industry," *EPRI Journal*, June 1982, pp. 6-15.
10. See Berg, pp. 36-37.

TMI-2: Making Strides in Research and Recovery

By Marie Mastin Newman

Government and industry research at Three Mile Island is a driving force behind efforts to recover the plant

For more than two years now, a multi-million-dollar research program has been underway at Three Mile Island (TMI) on the Susquehanna River near Harrisburg, Pennsylvania, to support and learn from the continuing efforts there to clean up the plant and recover from the accident that occurred on March 28, 1979. Compared to the publicity received by the accident, the research effort is little known. And yet, in the sense that TMI was a negative influence on the nuclear industry, the research program is a positive force, producing results and information that will help improve nuclear safety in the future.

The research effort is referred to as GEND, an acronym that collectively identifies the four utility and government organizations that are cooperating in the program: General Public Utilities Corporation (GPU), the owners of the TMI plant; the *E*lectric Power Research Institute (EPRI), the research arm of the electric utility industry; the *N*uclear Regulatory Commission (NRC), the government regulator of the nuclear power industry; and the *D*epartment of Energy (DOE), the federal energy research and development agency. The effort also involves a host of contracting organizations performing work both on- and off-site.

Among the four main cooperating organizations, DOE and EPRI are the primary funders of the research work. DOE has estimated that it will be spending a total of $123 million for the effort, and EPRI has committed $17.2 million over a five-year period. GPU maintains a base recovery effort directed toward decontaminating the plant (gathering up the loose fission products and disposing of them) and has expended the major portion of $300 million in property insurance funds as part of this work. Although these funds are not considered part of the research program, they have been essential to maintaining the plant in a safe, stable condition and to making progress toward its ultimate recovery. NRC maintains an office on the TMI site to facilitate carrying out its role of protecting the public health and safety during the recovery effort, but it is not actively involved in the work underway.

Research and recovery efforts overlap extensively at TMI. In fact, it is difficult for the outsider to differentiate between the two. At TMI, they enjoy a symbiotic relationship in most major areas of work. Sheldon Lefkowitz, president of Pentek, EPRI's contractor at TMI, explains why the two efforts are tied so closely together and why one really can't proceed without the other.

"Accomplishing the TMI recovery requires the unique utilization of existing technology and the development of new technology to the point that the major steps taken as you go along the recovery path are accomplished through R&D efforts. What in a normal situation would be strictly a clean up requires a research effort just to proceed because of the safety implications and the unknowns at TMI. And so the recovery effort has in fact become a research effort."

Among the major tasks accomplished so far at TMI as part of the cooperative effort have been the venting of krypton gas from the containment building in July 1980; the cleaning up of more than a million gallons of contaminated water, which was completed this spring; the preliminary decontamination of the containment building, also completed this spring; and the first look at the damaged core by an under-

Research and recovery efforts overlap extensively at TMI.

Marie Mastin Newman is a writer and communications consultant specializing in energy issues.

water TV camera this summer. GPU provided the funding for the venting of the gas and the water clean up. The decontamination and the underwater camera look were funded by both GPU and DOE.

Officials managing the GEND effort are enthusiastic about the progress being made and about the significant promise the work holds for the future of the industry. They stress that the research program offers both the government and the industry a unique opportunity to learn and to develop new technology that will make nuclear power safer in the future.

"This is a unique opportunity—an on-line, learn-as-you-go R&D program where the solutions are today."

"First of all, the TMI-2 accident is the most significant negative impact on the nuclear industry that we've had," remarks Adrian Roberts, manager of the research effort for EPRI. "Therefore, the timely, efficient recovery from this accident with the potential for requalifying this unit for service is probably the single most important thing that the nuclear industry can do.

"Second, TMI is the largest loss-of-coolant event ever occurring in a nuclear reactor. And therefore, the subsequent evaluation and recording of that event is important for the rest of the industry."

John C. DeVine, Jr., recovery engineering director for GPU Nuclear Corporation, the organization formed by GPU since the accident to manage its nuclear facilities, likens the situation to the process followed by the Federal Aviation Agency (FAA) after an air crash. "When a plane crashes, the FAA puts together every little piece physically so that it can understand exactly what happened. And this process has made air transportation much, much safer. We have the same opportunity here. In a crazy sense, the excellent safety record of nuclear power has been somewhat detrimental to us. We haven't had a good learning base for accidents. People have been very scared about hypothetical situations because they haven't had any real experience to correlate with. TMI gives us the opportunity to find out what really happens when you withhold cooling from the core."

Real-Time Results

Although planning for the GEND effort began soon after the accident, the program officially got underway in March 1980 when a coordination agreement was signed by the four participating organizations. The agreement formalized the roles of the participants and set down a series of major tasks. DOE's role at the time was limited. "It was originally thought that we would piggyback on the recovery effort," notes Willis Bixby, manager of DOE's TMI Site Office. "We were to be here when things happened rather than to be in a position of influencing them." The original DOE effort focused on collecting, analyzing, distributing, and preserving significant information. However, a series of events converged to cause DOE to rethink and eventually to expand its role, Bixby explains. First, a decision by the Pennsylvania Public Utilities Commission (PUC) in September 1980 prohibited the utility from using ratepayer funds for cleaning up the plant. This decision significantly restricted the recovery work, and efforts became limited to work directed toward specific projects. Second, the lack of funding led to the development of a cost-sharing plan proposed by Governor Dick Thornburgh in July 1981. Third, a new administration came into office with a positive attitude toward nuclear power and a belief that the impasse at TMI-2 in its unrecovered condition should be resolved. And finally, DOE saw "unique opportunities," says Bixby, in the work at TMI for the development of new technology for waste disposal and accident recovery. These forces resulted in an expanded role for DOE at TMI being endorsed by the Reagan Administration in October 1981. This role included the original data acquisition effort, and it established new work relating to waste immobilization and reactor evaluation.

Bixby stresses that the work DOE is funding is not research in the theoretical, abstract sense, but research that is results-oriented. On the wall of his office in the trailer he and his staff occupy at TMI is a sign that reads: "TMI is *not* a technological sandbox."

"That's to remind all the people that come in here that our work is applied R&D, not theoretical R&D," he explains. "This is a unique opportunity —an on-line, learn-as-you-go R&D program where the solutions are today. We're developing technology for acci-

dent recovery that didn't exist before. When we're faced with a technical problem, we don't have two or three years to come back with the solution. We have to go and get the best talent to do the job as quickly as possible."

One example Bixby offers as a positive result derived so far from the program relates to the effort shared by both DOE and EPRI to determine how well various components in the plant functioned during the accident. Did they do what they were supposed to do? Were they designed too conservatively? Not conservatively enough? Did they survive? DOE is responsible for examining instrumentation and electrical equipment (such as radiation monitors, resistance temperature devices, and vibration detectors) and EPRI is assessing the performance of various mechanical components (such as pumps, valves, parts of the polar crane, and the control rod drive mechanisms). One of the components removed and assessed by DOE was from a "loose parts monitoring system," a system put on plants to detect abnormal noises inside the reactor coolant system and to give information acoustically that might indicate a malfunction. Researchers determined that one of the amplifiers inside the component —a "field effect transistor"—did not perform well when it was subjected to radiation above a certain level. DOE notified the manufacturer of the device, who has since taken steps to make the transistor more radiation-resistant.

"What this points out is that we're getting some real-time, direct-benefit information of use to the industry," Bixby points out. "We concentrate on getting the lessons learned here at TMI directly back to the people who can use them—the industry—because they will in turn improve whatever deficiencies are present."

DOE and EPRI are also funding some major tasks that relate to assessing the post-accident environment inside the reactor building. One aspect of this work is designed to produce what Bixby terms a "mapping" of all the fission products, an inventory of where they all went in the reactor system. This information is important to the industry in terms of its "source term" assumptions. These assumptions are important in siting nuclear plants because they form the basis of calculations that determine what fraction of the fission products would reach the plant site boundary in the case of an accident and what kind of a dose they would impart to a person hypothetically standing there. "What TMI will do is to provide a data point to assess how those assumptions stack up against what really happened," states Bixby. Another aspect of the environ-

MILESTONES: TMI-2 Research and Recovery

	Completed or Targeted For Completion
■ Coordination Agreement Signed by GPU, DOE, EPRI, and NRC	March 26, 1980
■ 45,000 Curies of Krypton Gas Vented from Containment Building	July 1980
■ 500,000 Gallons of Water in Auxiliary Building Processed by EPICOR II	August 1980
■ 1st Highly Loaded EPICOR II Liner Shipped From TMI	May 1981
■ Submerged Demineralizer System (SDS) Built	September 1981
■ 600,000 Gallons of Water in Containment Building Processed Using SDS	March 1982
■ DOE-NRC Memorandum of Understanding Signed Identifying TMI-2 Wastes That DOE Can Use as Part of Its R&D Program and Stating Procedures For this Effort	March 15, 1982
■ Agreement in Principle Signed by DOE and GPU for DOE to Acquire Damaged Core	April 8, 1982
■ Large Decontamination Experiment Completed By GPU	April 1982
■ 1st SDS Container Shipped from TMI	May 1982
■ 1st Visual Examination of Core Using Underwater Camera	July 1982
■ 100,000 Gallons of Water in Reactor Coolant System Processed Using SDS	September 1982
■ High Integrity Container Developed By DOE for EPICOR Disposal	September 1982
■ All SDS and EPICOR Wastes Shipped Off Island	July 1983
■ Reactor Vessel Head Removed	Spring 1983
■ Fuel Removed from Island	1984/1985

ment work is to characterize the hydrogen burn that occurred during the accident. DOE has been emphasizing this work during fiscal year 1982 and EPRI has also been involved in it.

Decontamination is, of course, a major work area shared by the GEND participants. In the R&D program, DOE is responsible for studies relating to decontaminating the containment building, while EPRI is funding efforts to decontaminate the reactor coolant system (RCS) and the auxiliary system.

One of the major challenges at TMI-2 has been how to deal with the large amount of highly contaminated waste water. . . .

One of the major challenges at TMI-2 has been how to deal with the large amount of highly contaminated waste water that was left after the accident: 500,000 gallons in tanks in the auxiliary building and 600,000 gallons in the basement of the containment building. "It was a dangerous situation," conceeds GPU's DeVine. "Water is mobile; it can leak and spill. Tanks can rupture. We're on an island. The potential for communicating it to the environment was real."

Attacking the problem required designing, building, installing, and operating two major new processing systems for removing the radioactive material from the water: the EPICOR II and the SDS systems.

"These are called ion exchange systems and they work like water softeners in the home," explains DeVine. "They strip dissolved radioactive particles from the water and attach them to a special material called ion exchange resins. What you have left after the systems work is residual cleaned-up water on the one hand and concentrated radioactive material on the other."

The EPICOR II system was built to process the water in the auxiliary building, a job which was completed in August 1980. The process left behind 50 large (4' x 4') disposable canisters containing the ion exchange material that had captured 99 percent of the radioactivity from the 500,000 gallons of water, plus the cleaned-up water. (A very small amount of radioactivity was collected by 25 additional canisters that have already been shipped off the island for disposal at a commercial burial ground.)

The 600,000 gallons of water flooding the basement of the containment building were much more highly contaminated than the water in the auxiliary building, notes DeVine. The principal contaminant was cesium 137. "It would have been unsafe to try to use the EPICOR system for that water," he explains. Therefore, researchers built the Submerged Demineralizer System (SDS) especially for the containment building water and designed it to operate underwater to provide shielding and protection for the workers who would stand above it. The system was built in an empty pool in the Unit 2 fuel handling building and the pool was flooded with water. (The fuel handling building, the earthquake-proof building in a nuclear plant that is connected physically to the containment building, normally is used to store spent fuel. Because TMI-2 was a fairly new plant at the time of the accident, it had not yet accumulated any spent fuel.) The SDS consists of a series of stainless steel canisters containing a special, sand-like ion exchange material called zeolite. It is connected by pipes and hoses to the containment building and operated with remote tools. Contaminated water is pumped through the system, and the zeolite strips off the radioactive particles. After the water leaves the SDS canisters, it also goes through the EPICOR II system for a final polishing.

The SDS began processing water in September 1981 and finished the bulk of the task in March 1982. The system was then adapted for processing 100,000 gallons of contaminated water contained within the reactor coolant system. That task is now underway and GPU expects it to be completed by the end of this year.

The decontaminated water from both the auxiliary and the containment buildings is being stored at the TMI site in two large tanks. The 50 EPICOR canisters plus 10–20 stainless steel canisters (each the size of a garbage can) from the SDS processing are among the wastes at TMI that must be safely disposed of. Some of these wastes—from both the accident and the recovery—are similar to the low level wastes normally generated by commercial nuclear plants. Others, such as the SDS liners and the majority of the EPICOR wastes, are much more highly radioactive and are not suitable for storage in their present form at commercial sites. Therefore, DOE, as part of its ex-

panded role at TMI, has agreed to remove and dispose of them.

"Our principal emphasis has been in the shipping, vitrification, and R&D disposition of the SDS liners," explains DOE's Bixby. Plans call for the SDS liners to be shipped to DOE's Pacific Northwest Laboratory in Richland, Washington, and for three of them to be converted to glass by the vitrification process. The remainder will be buried as part of an R&D program. The first of these liners was shipped to Richland this May in a 12-ton container designed to withstand all perceived accident conditions such as sudden impacts at high speeds, high temperature fires, and immersion in water.

One of the 50 EPICOR II liners has already been shipped to DOE's Idaho National Engineering Laboratory for use in an R&D program. DOE has developed a "High Integrity Container" to allow safe disposal of the liners at commercial licensed low-level waste burial sites. The technology used to develop the container will also be available for use by the industry in disposing of wastes from commercial power plants. Two prototype containers were to be delivered to Idaho for testing this fall. If the testing is successful, DOE plans to arrange for disposal of some of the EPICOR liners in the high integrity containers at a commercial site. DOE and GPU hope to have all of the SDS and EPICOR wastes off the island by next summer.

In addition to the large amount of contaminated waste water in the TMI-2 containment building, the owners were faced with an extensive amount of radioactive contamination on the floors, walls, and other surfaces. This year GPU conducted a large scale decontamination experiment funded partly by DOE that was successful in reducing radioactivity in certain areas in the containment building and, therefore, in making working conditions less cumbersome. In the experiment, the floors at certain levels were sprayed with high pressure water, while other components, such as the polar crane, were sprayed with low pressure water.

EPRI's role in decontamination is directed toward removing the radioactive material deposited primarily on the pipes in the reactor coolant system and the auxiliary system. Technical planning for the work, which will be carried out by the Bechtel Corporation,

TMI-2 Entries: People Progress in Difficult Conditions

As of mid-July, there had been more than 60 entries by teams of workers into contaminated buildings at TMI to perform such tasks as basic decontamination (scrubbing, washing, etc.), maintenance, taking radiation surveys and photographs, installing equipment, and removing samples of equipment or material inside the buildings. Who are the people that are carrying out this work? They include volunteers from all parts of the GPU system—meter readers, linesmen, engineers—who are paid at their regular rates, as well as engineers and workers from some of the contracting organizations at TMI such as Bechtel. They are men and women alike. The first woman to enter the reactor building was 26-year-old Beverly Della Loggia, a radiological engineer at TMI who spent 44 minutes installing two radiation monitors.

"It looked the same as any other reactor building," said Della Loggia. "It was exciting to have the opportunity to make the entry. But it was a fairly routine operation. All this one required was additional protective clothing and precautions."

All workers receive an "extraordinary" amount of training prior to their entry into the building, according to GPU Nuclear Corporation's Director of Recovery Engineering John C. DeVine, Jr. They have to learn the correct use of their breathing systems and other instruments, how to dress and undress, and how to carry out their specific tasks. Mock-ups are built and workers spend about a week rehearsing and preparing for their entries. According to DeVine, workers wear several layers of protective clothing. Each layer is composed of tightly-woven cotton and includes a suit, booties, gloves, hoods—"kind of an Easter bunny outfit," he laughs. Two to four layers of this clothing are worn depending on the degree of radioactivity that the workers may encounter. On top of these layers, depending on the specific job at hand, additional plastic covers can be worn that act like a rainsuit to prevent the absorption of radiological material. Some jobs require boots similar to those worn by firemen.

Because of the extensive protective clothing workers must wear, they face the potential problem of heat stress and must be tested for their ability to handle the heat. To help alleviate the heat problem, some workers have worn a new piece of protective clothing called an "ice vest." Designed to reduce heat stress, this item was developed by Pennsylvania State University and tested by EPRI (as part of another program in its Nuclear Division) and GPU Nuclear's Industrial Safety and Health Department. The ice vest is a shirt made of insulating material with many pockets containing small ice packs. Tests have shown that the garment can lengthen the time a worker can spend inside the reactor building.

In addition to the protective clothing, all workers wear respirators that remove radioactive particles from the air they breathe. They also carry multiple devices for measuring radioactivity, and if the job requires handling radioactive substances, they wear special rings to measure the radioactivity received by the fingers. If they climb, they wear safety harnesses.

"It's simply a matter of being careful and prudent about work in a potentially hazardous environment," states DeVine. "The work isn't glamorous. And yet, we're developing a lot of new techniques here and are learning a lot about how to work more efficiently. TMI is a real laboratory for this kind of work."

has begun. EPRI's Adrian Roberts explains that as part of this work researchers will be investigating new methods for decontaminating pressurized water reactors (PWRs), such as chemical cleaning methods, that will be applicable to the industry in a broader sense.

"The more than 50 PWRs operating in this country all have some level of contamination because they have been operating for several years. What we're doing would be applicable to them. The program will not only provide new technology for PWR decontamination —more importantly, it will provide a demonstration of that technology. You know, nobody wants you on their site cleaning up something that really isn't all that dirty. Here we have a site that urgently needs cleaning. So we have a large prototypic system as a test ground for using new approaches to decontamination."

As a longer term responsibility, EPRI will be funding efforts to determine how to go about requalifying the TMI-2 unit, i.e., getting it back on line.

"It's way down the pike but we have to start thinking about it," says Roberts. "We'll need new tools to show that there are no cracks in the reactor vessel and other primary components, for example." Also as part of this task, EPRI will be helping to establish requirements for requalifying the reactor vessel and for characterizing material degradation that may have occurred.

Examining the Core

Well before any decision can be made about requalifying the reactor, extensive examination of the core and removal of its 133 tons of fuel will have to take place. DOE has the lead responsibility in the research effort to characterize the condition of the core and Bechtel is the prime contractor. In April of this year, DOE and GPU signed an agreement in principle for DOE to acquire all of the core for R&D purposes. Although final shipping of the core off the island is not expected to occur until 1984 or 1985 and is contingent on GPU funding availability, certain steps have already been taken to examine it and gain information of significance to the industry and the government. GPU completed a test program this summer that involved moving some control rods inside the reactor to take electrical and acoustical data to obtain evidence of the condition inside the reactor. On July 21 of this year, researchers lowered a small, underwater TV camera into the

TV Camera Used to Examine Core

A major milestone in the TMI-2 research and recovery effort occurred this summer when researchers lowered a miniature underwater television camera into the damaged reactor and obtained their first looks at the core since the 1979 accident. No evidence of melted fuel pellets was found, although, as expected, there appeared to be evidence of partial melting of non-fuel materials that have melting points much lower than uranium oxide fuel. Officials said later that the experiment was "extraordinarily useful" in helping to determine the condition of the core and to facilitate its removal from the island.

"We took a quantum leap forward in knowledge of what the actual condition of the core is," notes GPU's John C. DeVine, Jr. "In terms of the quality of the pictures and the usefulness of the footage, we were quite successful."

The camera examination process began on July 19, when technicians removed a 24-foot long leadscrew which was connected to the reactor's control rod drive mechanism. (This is the mechanism used to move the control rods that regulate the fission process). Removal of the screw left a hole 1½ inches in diameter going down to the top of the core. Then, on July 21, technicians standing on top of the reactor's service structure lowered the camera through the opening and guided it remotely into the center of the core where videotape pictures were taken for about two hours.

The pictures confirmed earlier estimates that the core was severely damaged by the 1979 accident, GPU Nuclear officials said later. Although no visible damage was shown to the reactor's internal components above the fuel section, it was apparent that a large section of material was displaced from the center of the core. "The pictures showed a fairly large crater at the top center of the core," noted DeVine. Five feet below that appeared a bed of rubble.

Subsequent examinations made in early August, which focused on the edge of the core and a point midway between the center and the edge, showed that the five-foot-deep void where fuel assemblies once were extends from the core's center about halfway to its edge. The view of the intermediate point showed a bed of rubble at the five-foot depth, but more recognizable components were also seen—springs, tubular pieces and parts of fuel assemblies hanging from the plenum, the section of the reactor between its head and the fuel. The plenum itself appeared to be substantially undamaged. At the edge of the core, the camera found the top of a control element assembly at its proper location. That blocked the camera's further movement, but suggests that the void does not extend to the edge of the core.

Industry officials point out that the pictures did not reveal anything unexpected. "What we observed is consistent with analysis of the expected damage made several years ago by industry and government groups," notes EPRI's Adrian Roberts. "This analysis, in turn, was based on the industry's codes and models that predict what will happen to the core during a loss-of-coolant accident."

Officials point out that only a limited part of the core was seen during the camera examination. Additional analysis of the videotapes and the possibility of other camera inspections are now under consideration. The leadscrews will also be further analyzed to get a clearer picture of the contaminants inside the reactor.

core to obtain the first visual look at the inside of the reactor vessel and the fuel since the accident.

Researchers are looking forward to another major milestone early next year—removing the reactor vessel head. They will also start engineering for removal of the plenum, which is the section of the reactor between its head and the fuel.

The core damage assessment efforts at TMI are very significant to the nuclear industry because they will provide important information to verify the industry's computer codes that predict the sequence of core damage in a loss-of-coolant accident. Removal and examination of the TMI-2 core is a key part of an industry program now underway called IDCOR—Industry Degraded Core Rulemaking program. This program consists of a series of experiments and analyses to satisfy the NRC that the current computer codes are correct or that they will be improved upon if necessary. At one time the NRC had informed the industry that it intended to proceed with a degraded core rulemaking, but has since recently floated proposals that would de-emphasize the rulemaking aspect and that could achieve a regulatory decision within a reasonable time period. This change is partially the result of the effort expended by the industry on its IDCOR program in putting its data base in order, explains Adrian Roberts: "Examination of the TMI-2 core will be a major contributor to this data base. It's the only prototype core ever damaged to the degree that it needs assessment."

Removal of the core and completion of the research and recovery efforts at TMI are contingent upon increased funding being made available. GPU's $300 million in property insurance funds is almost depleted and the owners estimate that some $760 million is still needed to complete the clean up. Even after the infusion of $123 million in R&D funds from DOE and $17.2 million from EPRI, it's obvious that the job cannot be completed without substantial additional funding. The Pennsylvania PUC approved a formula that would make available ratepayer funding to GPU but not enough to complete the clean up. Moreover, that funding is tied to the restart of Unit 1, an event for which a date has not yet been determined. Efforts are underway at the state and national level in both government and industry to raise the remaining necessary clean-up funds, but no definite results have been reached.

Yet, even with the funding situation clouded, work is proceeding and progress is being made at TMI.

Yet, even with the funding situation clouded, work is proceeding and progress is being made at TMI. "We've made some real strides here," states GPU's DeVine. "There has been some good, first-class technical work done. I think the general perception on the outside is that we're just sitting around waiting for the wheelbarrow of money to show up before we start to work, and that's just not the case. Certainly we could do more; we could move faster. We're funding-limited in a lot of programs. But people are really working and making some good progress in tough areas."

Researchers are enthusiastic about the results and the team spirit that has developed among the organizations cooperating in the GEND effort. "TMI has become a unit," affirms DOE's Bixby. "We have a common bond to move as quickly as possible in removing the core."

Be
Bright
Conserve
Light
Turn
It
OFF!

The Power of Energy Education

by Ernest J. Roberson and Fred C. Niedermeyer
with Kathy Renner

The Energy Source Program will give students across the country a life-long awareness of energy issues

"Since the 1970s world crude oil prices have shot up about 1,000 percent. The reasons for this are complex and difficult to communicate under the best of circumstances. But they are almost impossible to communicate to a public with little or no educational background about the issues."

This is how E. M. (Mo) Benson, Jr., Vice Chairman of Atlantic Richfield Company, explains what encouraged ARCO to become actively involved in a new in-depth energy education program for youngsters from kindergarten through high school.

"The energy shocks of the seventies awakened those of us in the industry to the lack of public understanding of even basic energy issues," Benson continued in a recent speech to industry colleagues and educators in Los Angeles. "In searching for causes, we discovered there was little or no systematic instruction in our schools on an issue which will have a profound effect on this and future generations."

ARCO is just one of the industry leaders who supported the development of the first comprehensive nationwide energy-education curriculum: the Energy Source Program. Other energy-industry sponsors included the American Gas Association and the Edison Electric Institute. The product of three years of extensive field testing and development by key educators and energy executives, the program is the first energy-education tool of such scope and quality to be team-sponsored by educators and business. And, according to experts in their respective fields, it is the first program which gives balanced coverage to different energy sources and issues—present sources, future sources, conservation, environment, and costs. The program now has six different grade-level study units for kindergarten through junior high school ready for the classroom. Senior high materials will be complete next year.

Energy Source is designed to give young people a broad and balanced perspective on energy resources, uses, and challenges. The ultimate intent of Energy Source is to encourage long-term internalized values and attitudes. It is believed that energy education during their formative years will help students develop a life-long awareness of energy news. As a result, these consumers and rate-payers of tomorrow will be able to vote knowledgeably on energy issues and to conserve energy —that is, to use energy wisely—as a matter of principle and national interest rather than solely because of cost.

Stemming from a school program developed by San Diego Gas & Electric (SDG&E) for its service area, Energy Source grew out of a series of meetings between Westinghouse Electric Corporation, SDG&E, and Energex, a firm specializing in curriculum development, program evaluation, and implementation. Because of its achievements with the earlier SDG&E program and its development of major instructional programs with the Dairy Council of California and California Solid Waste Management Board, Energex was contracted to develop the program. The management team that oversees and coordinates the project consists of Mike Mangan (Manager, Nuclear Information & Educational Programs) of Westinghouse, Ernest Roberson of San Diego Gas & Electric, and Myrna Plost (Director, Educational Programs) of Atlantic Richfield. Total industry sponsorship of the program's development and testing approaches $1 million.

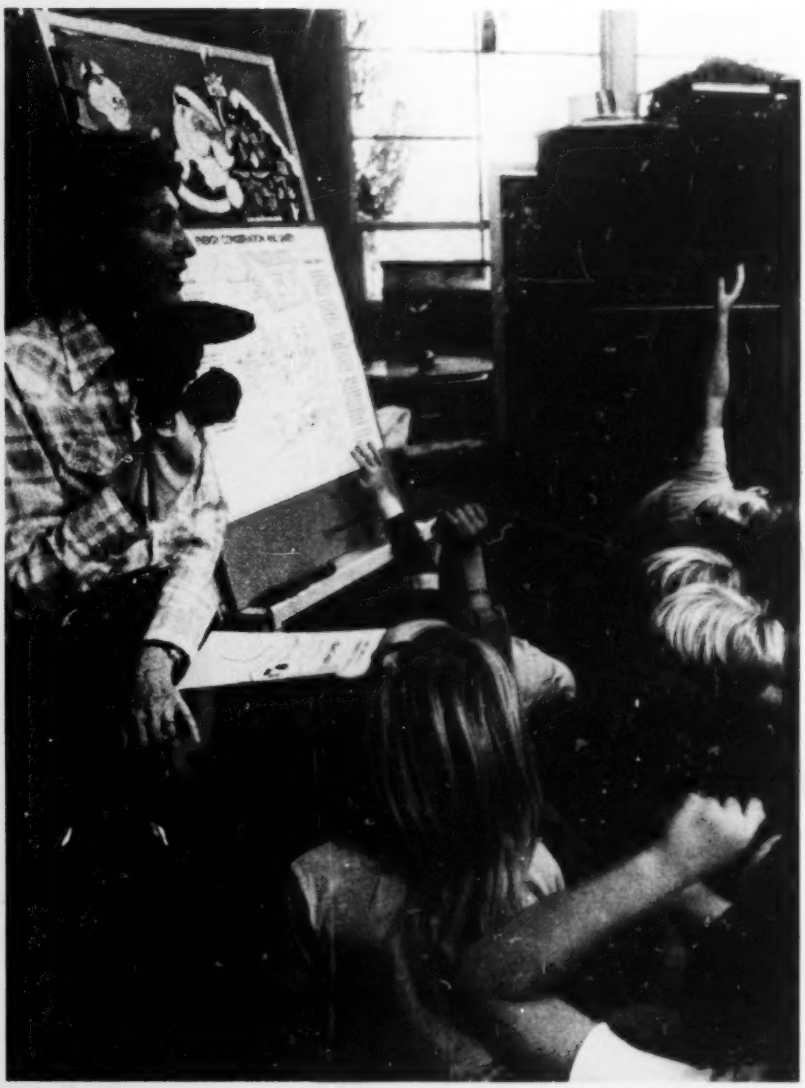
The finished product, created through the collaborative efforts of the

. . . the program is the first energy-education tool of such scope and quality to be team-sponsored by educators and business.

Ernest J. Roberson is Educational Services Supervisor for San Diego Gas & Electric and Co-manager of The Energy Source Program.
Dr. Fred C. Niedermeyer is President of Energex Energy Education of Lakewood, California, developers and distributors of the Energy Source Program.
Kathy Renner is a free-lance writer who works in the San Diego area.

developers, the management team, and the industry/educator advisory council, is a set of sequential energy-education units. Although each unit is self-contained and stands alone, the complete program is a series for children through the secondary school level. Despite its specialized nature, Energy Source is designed to enable teachers with little or no background in energy to teach it successfully. A Teacher's Guide clearly outlines lesson plans for daily 20- to 45-minute sessions. The Guide includes procedures for conducting class lessons, materials for projects, and guidelines for discussion. Each unit of instruction is completed in two to three weeks.

Student interest is sparked by colorful entertaining filmstrips and by cassette tapes which creatively introduce energy concepts. Kindergarteners are entertained by Offalot, a hand puppet that remembers to turn things off to save energy. The elementary school units feature 16- to 24-page workbooks with easy to read texts about imaginative places like Fossil Fuel Junction and Brightland. The two junior high school units each include 48-page illustrated student texts featuring theme characters such as Sy Malone, a fictitious energy sleuth who tracks down energy solutions.



Kindergarteners are entertained by Offalot, a hand puppet that remembers to turn things off to save energy.

Each unit gives practical guidelines and information about energy that can be applied daily by the students who use the unit. For example, the Offalot group concentrates on recognizing various home energy users and knowing what they do. These busy kindergarteners—often the ones leaving refrigerator doors open and hot water running—learn to identify situations where energy is being used and is costing Mom and Dad money. From there they are taught how to use energy wisely. They also learn safety measures to apply when using home appliances.

At the more advanced end of the Energy Source program, junior high school youngsters are expected to learn basic energy terms and concepts, including primary and secondary energy sources, potential and kinetic energy, energy conversions, and conversion efficiency. They also probe the political, environmental, and economic issues surrounding energy.

Home activity booklets are an integral part of the program. These take-home exercises allow parents to follow along and to reinforce what is being learned at school. One suggested home activity for beginners is a room-by-room energy tour to find the furnace, water heater, and other energy users. Older students are asked to conduct energy audits of their homes.

Project coordinators emphasize that these materials and ideas "didn't just happen." Energy Source is the result of a diligent commitment on the part of its creators to develop an energy-education program that meets the same requirements for educational integrity and thoroughness that any other innovative curriculum should meet. Far from the one-shot efforts by individual industries in the past—the films or materials that usually dealt with only one

aspect of the larger energy picture—Energy Source was to become a comprehensive, permanent program that would be continually updated. Before it could be released, educators and energy industry representatives alike had to agree it was state-of-the-art. Toward these goals, Energy Source was submitted to a nationwide field test in which it was used and evaluated by thousands of students and more than one hundred teachers before it emerged as an in-depth full-fledged academic program.

Nationwide Testing

Last year at this time 4 elementary level Energy Source Units were field tested at 9 sites in 7 states. They were used by more than 3,000 students from 122 classrooms in 33 schools.

Various project sponsors across the country volunteered to coordinate field tests in their areas. ARCO spearheaded the field testing in Colorado, Ashland Oil Incorporated in Kentucky, Pacific Gas and Electric Company in Northern California, SDG&E and Southern California Gas Company in Southern California, Energy and Man's Environment in Utah, Wisconsin Electric Power Company in Wisconsin, and Oklahomans for Energy & Jobs in Oklahoma.

On the basis of socio-economic levels, the field test population included 33 percent low or low-to-middle income classes, 56 percent middle income classes, and 11 percent high income classes.

The field test was conducted to determine student and teacher attitudes and to monitor the level of learning from each unit. To help measure how much the children knew about energy before undertaking this study, the first classroom session began with a pretest. For example, after looking at pictures of machines and appliances, second graders were asked to tell which ones run on electricity, natural gas, heating oil, or gasoline. Older elementary students faced more difficult pretest exercises, such as answering the following question: "This fossil fuel is taken from the ground and cleaned. An odor is added to it. Then it is sent in underground pipelines to homes, factories, and businesses. There it is used to run various appliances and for heating. What fossil fuel is this?"

The mean pretest scores were slightly higher than what would be expected if children had simply guessed randomly:

For 757 first and second graders—66 percent,

For 836 third and fourth graders—43 percent,

And for 1,057 fifth and sixth graders—55 percent.

Still, the pretest scores confirmed that students from all socio-economic backgrounds and grade levels need energy enlightenment.

After completing the units, the students were given another test to measure learning. Mean scores on posttests for the same first and second graders increased to 92 percent. Third and fourth graders moved up to 85 percent, and fifth and sixth graders followed suit with 85 percent. Clearly, substantial learning took place as a result of energy instruction.

Clearly, substantial learning took place as a result of energy instruction.

A similar testing process was conducted for the two junior high school units. In the same pattern, pupils who ranked in the lowest score categories on the pretest achieved at the highest score categories on the posttest.

Relying on the candid nature of children for honest feedback, program coordinators polled students upon completion of the Energy Source program. One exuberant kindergartener

More information on the Energy Source program can be obtained from Energy Source Energy Education Program, 5505 East Carson Street, Suite 250, Lakewood, CA 90713, (213) 420-6814.

Representatives of the following groups currently participate on the Energy Source Advisory Council:
American Gas Association
Ashland Oil, Inc.
Atlantic Richfield Company
Chevron, U.S.A., Inc.
Edison Electric Institute
Joint Council on Economic Education
National Council for the Social Studies
National Education Association
National Parent Teacher Association
National Science Teachers Association
Northern States Power Company
Oklahomans for Energy & Jobs
San Diego County Department of Education
San Diego Gas & Electric
Southern California Gas Company
Westinghouse Electric Corporation
Wisconsin Electric Power Company

said, "I like everything, every single thing." Overall, 92 percent of the children said they liked learning about energy. And 90 percent said they will try to save energy at home, now that they've learned about it in school.

Through follow-up questionnaires, teacher response also provided valuable insight and direction. All of the participating 122 teachers felt students had a positive reaction to the program. All but 5 of the teachers felt the program's content was objective and balanced, covering a good cross-section of the energy issues. Several teachers commented that they had learned a lot about energy themselves and that they had received enthusiastic support from parents. After compiling all the teachers' data, developers of Energy Source shortened some units and expanded others, added more practice exercises, increased the number of visual aids, added color and enlarged type in workbooks, revised filmstrips, and adjusted the Teacher's Guide. Through this extensive refinement process—the work of a partnership among teachers, students, and energy-industry representatives—Energy Source was made even more effective, accurate, and entertaining than it had been in the field test.

Unit by unit

Offalot
Level: Kindergarten
Offalot is a furry little creature who turns things "off a lot"—things like TVs or lights that aren't being used. The Offalot hand puppet helps teacher do the explaining. And Offalot shows up in a series of picture exercises and posters which distinguish between good and poor energy-use practices.

Learning Objectives:
- Recognize home energy users
- Identify when energy costs money
- Learn wise energy use habits
- Use precautions around home appliances

Brightland
Level: Grade 1 or 2
The King and Queen of Brightland plan a winter festival. But, alas, there is so much to prepare that they can't possibly get ready in time! After doing a good deed for a Wizard, the Wizard pays them back with the gift of energy. And look at what a difference energy makes. Brightland comes alive, and the Winter Festival is a smashing success.

Learning Objectives:
- Learn how energy comes to us
- Identify appliances run by different fuels
- Identify when energy produces heat, light, or motion
- Assess your own energy habits

Fossile Fuel Junction
Level: Grade 3 or 4
The folks at Fossil Fuel Junction know all about fossil fuels and why they should be conserved. When Sheriff Crockett hears that Dewey Dolittle and his gang of energy wasters are coming to town, he gathers up an energy posse to meet Dewey's train. After a little convincing, Dewey decides to become an energy-saver instead of an energy-waster.

Learning Objectives:
- Learn facts about fossil fuels and their production
- Recognize everyday products made from fossil fuels
- Keep a record of energy conservation efforts

Local Sponsorship

Now, with thoroughly tested and revised materials, the Energy Source management team faces the task of building a network of local sponsors who will actually implement the program. The program's distribution will rely primarily on local utilities and other energy-related industries willing to buy the materials, to work with school district personnel to install them, and to offer schools Energy Source at no charge. In our current economic environment, industry sponsorship is vital if large numbers of students are to have these programs in their classrooms.

The purchase price of Energy Source is approximately one dollar per student for the initial set of classroom materials and 75 cents per student for a replacement set, since some materials are reusable. The more schools which are involved, the greater the cost-effectiveness. ARCO's Mo Benson calls Energy Source "perhaps the best educational bargain available today."

Sponsors already involved in Energy Source, such as Carl Lehmann (Administrator, Community Information) and Richard Stanford (Educational Liaison) of Northern States Power, who are supervising the distribution in the Minneapolis/St. Paul area, say interaction with educators is creating considerable good will and a better working relationship between their company and the schools.

Convinced of the program's value, a consortium of sponsors in the Los Angeles area has formed a local non-profit organization, the Energy Source Education Council. The Council's goal is to

give at least half (540,000) of the elementary and secondary students in the greater Los Angeles area Energy Source instruction each year. Based on the Council's five-year plan, projected costs for the first year are $300,000. To be on the Council's board, member companies are each asked to contribute $25,000 or more. The board decides which school districts should participate. A contribution of $10,000 or more is needed for advisory committee membership. The advisory committee joins with educators to help determine the direction of the program in the Los Angeles area. Similar coalitions are being considered in other cities across the country.

Industry sponsors are supplied with an Energy Source implementation plan designed to encourage maximum school participation and to increase cost efficiency. The strategy begins by explaining the program to the school district's superintendent and by obtaining approval to announce and conduct voluntary teacher orientation meetings. At some point, the sponsor may be asked to present the program at a principal's meeting. Often a school district will adopt Energy Source as part of its regular curriculum for all teachers at the designated grade levels.

Working through these channels, sponsors can expect attendance at subsequent teacher orientations to be high because the district will encourage teachers to attend. And, when teachers invest time in a meeting to hear about Energy Source, two important things are accomplished. First, teachers become enthusiastic about the subject of energy. Second, after taking their own time to review the materials, teachers are more likely to use them effectively in the classroom. The key, of course, is to provide attractive, stimulating energy-education materials that teachers will want to use year after year.

These orientation meetings need not be long or elaborate. Their major intent is to motivate teachers. Glancing through the easy-to-follow lesson plans and seeing the variety of colorful visual aids are enough to convince teachers that this is a worthwhile and exciting field of study.

Although time with teachers during implementation can be minimized, time and effort on the part of the sponsoring company cannot be underestimated. Soliciting school district support, scheduling and conducting a series of teacher orientations, monitoring teachers' use of the program, and resupplying materials each year all require a lot of sponsor attention. Companies going into this type of implementation may need to expand their school education staffs.

Helping children—tomorrow's bill-payers and voters—become aware of where energy comes from and how it is used is of critical importance. For Energy Source sponsors, perhaps the best way to think of funding this curriculum is both as a short-term expense intended to save energy now through conservation and as a long-term investment in our energy future. In the latter

Power Switch
Level: Grade 5 or 6
Whimsical-looking creatures representing each fossil fuel are working harder and harder to supply people with energy. But as people need more and more energy, our friends become drained. That's why some people are looking for alternative sources of energy—solar, nuclear, and geothermal—to give our fossil fuel friends the help they need.

Learning Objectives:
- Learn sequence of fuel eras
- Identify energy sources and their production
- Understand the advantages and disadvantages of each energy source

Energy Crunch
Level: Junior High Science
Sy Malone is an energy sleuth. He's working on the energy crunch case. He tracks down the causes of the problem and comes up with some ways we can solve it.

Learning Objectives:
- Prove problems of supply vs. demand
- Study aspects of energy conservation on a large scale
- Understand facts about present and future energy sources
- Learn specifics about each energy source: supply, costs, efficiency, environment, technology

Energy in American History
Level: Junior High Social Studies
Viola Strangeways is a wacky inventor whose inventions include a time-warp computer named Rex. Viola and Rex travel back in time to examine how energy has affected the history of the United States.

Learning Objectives:
- Examine trends in energy growth during the last 200 years
- Evaluate changes in America's fuel mix
- Recognize today's energy crunch
- Study important energy-related discoveries
- Identify lifestyle changes as a result of energy use

case, the purpose of the expenditure is not unlike that for energy research and development efforts—both are expected to pay off at some future time.

Wherever Energy Source has been used, students have learned objective up-to-date information on energy. The program has cut through all variables of socio-economic status and abilities. Students, teachers, and parents agree Energy Source sheds new light on attitudes and awareness about energy conservation and costs. Observes ARCO's Benson, "A sound energy program such as this benefits not only companies directly in the energy business, but all industry which depends on energy. The energy economy and the U.S. economy are increasingly one and the same."

The Wrong Answers to the Right Questions

By Bernard L. Cohen

Journalists are misinforming the public about the scientific community's assessment of radiation's health effects

Dr. Bernard Cohen offers one analysis of the breakdown in communication between the scientific community and the public. Other viewpoints do exist.

The Editorial Board of *Electric Perspectives* invites readers to contribute their perspectives on the communication process and especially welcomes recommendations for improving it.

When a public policy issue arises that involves questions of scientific fact, the public is entitled to receive the scientific community's answers to those questions. But scientists have little direct access to the public. Rarely are they talented and experienced enough in popular writing to get articles published in widely circulated magazines and newspapers, and they have virtually no access to television or radio programmers. Consequently, their findings must be transmitted to the public by journalists.

How well does this communication system work? Let us examine one of the many scientific considerations involved in the current debate about nuclear energy—radiation's health effects. The resolution of that debate depends in large part on how dangerous the public perceives radiation to be. Surely they deserve to be informed of the scientific community's assessment of the danger radiation poses to human health.

A review of journalists' reports about radiation shows that the communication process has broken down. They have broadcast the wrong answer to a purely scientific yes-or-no question, and they have distorted the answer to a relative question by failing to put it in its proper context.

A Yes for a No

In 1972, two prestigious scientific groups released reports on studies they had conducted independently to develop quantitative estimates of the cancer risk presented by low-level radiation.[1] Their findings were essentially universally accepted at that time. In recent years however, there have been claims that these estimates were much too low and that low-level radiation is much more dangerous than the studies indicate. These claims have now become an issue of widespread public concern.

Is radiation much more dangerous than indicated by the 1972 assessment?

The question is clearly a strictly scientific one with no room for nonscientific considerations, and the scientific community has time-honored ways of answering such questions. Scientists from all over the world do experiments, collect data, analyze available information, develop theories, devise and carry out tests for these theories, and publish their results in scientific journals. There would be several dozen articles of considerable relevance and several hundred others of peripheral interest published. In addition, scientists present papers on their work at meetings where there is ample time for questioning, discussion, and criticism. These exchanges often prompt scientists to further investigate the subject by cross-checking results and repeating questionable experiments. Unless the problem is unusually difficult, a consensus to which at least 90 percent of involved scientists agree is generally reached rather rapidly.

A review of journalists' reports about radiation shows that the communication process has broken down.

Bernard L. Cohen, recipient of the 1981 American Physical Society Bonner Prize for Nuclear Physics, is Professor of Physics and Chemical and Petroleum Engineering at the University of Pittsburgh.

On a question of such significance, prestigious scientific committees—like the National Academy of Sciences' Committee on *B*iological *E*ffects of *I*onizing *R*adiation (BEIR), the United Nations' Scientific Committee on Effects of Atomic Radiation, the International Commission on Radiological Protection, the U.S. National Council on Radiation and Measurements, and the United Kingdom National Radiological Protection Board—also evaluate the evidence.[2]

Journalists have largely ignored . . . the multitude of scientific papers that give a direct NO answer to our question.

On the question at issue here, the consensus of the involved scientific community and the unanimous decision of all the prestigious groups mentioned is that the answer is NO, radiation is not much more dangerous than indicated by the 1972 studies.

How well have journalists transmitted this decision to the public? The only evaluation from the scientific groups given wide publicity was the BEIR Committee's report. That Committee was split on the far more difficult question of whether low level radiation is *less* dangerous than indicated by the 1972 studies. The journalistic reports interpreted this to mean that the Committee was indecisive on the entire question of hazards from low-level radiation. Actually, the Committee was completely clear on the question at hand, stating that there is "no substance" to the proposed evidence that radiation is much more dangerous than previously indicated.

Journalists focused most of their attention on a single article, commonly referred to as "The Mancuso Study," that purported to give a YES answer to the question at hand, although even by the authors' own admission this was a tentative result.[3] Well over 20 critiques of the Mancuso Study have now appeared, including 3 reanalyses of the same data which arrived at contrary conclusions.[4] But, there has been almost no journalistic coverage of any of the work refuting the Mancuso Study. The New York Times Information Bank lists 12 entries on Mancuso and only 1 on his critics.

Similarly, a long newspaper story gave national coverage to an article authored by I. Bross and associates that purported to give evidence for a YES answer to our question. The press report never mentioned the devastating critique of the article, written by two distinguished scientists from the National Cancer Institute, which immediately followed the Bross article in the very same scientific journal.[5] The press also gave national coverage to report by T. Najarian of excess cancers among workers at the Portsmouth, New Hampshire, naval shipyard.[6] The report gave a tentative YES answer to the question at hand, but when more evidence became available the author withdrew most of its claims. The press virtually ignored both the withdrawal and the heavy criticism directed at the small part of the report that was not withdrawn. Likewise, journalists frequently have inferred a YES answer from reports of excess cancer among civilians exposed to bomb test fallout, reports that are, by the way, based on very flimsy evidence. How can the inference be valid when there are no reliable data on radiation exposure to these people? Without that data, the reports could not possibly give the quantitative information needed to answer our question.

Journalists have largely ignored not only the scientific critiques of the reports that purport to give a YES answer, but also the multitude of scientific papers that give a direct NO answer to our question. For example, there have been important developments in the theory of how radiation induces cancer,[7] much better animal data have been collected in the low dose region,[8] much new information has been obtained on the relationship between radiation and chromosome aberrations,[9] and further follow-up has become available on the Japanese atomic bomb survivors,[10] all indicating a NO answer. Moreover, some of these and other papers give the opposite answer—low levels of radiation are *less* dangerous than indicated by the 1972 studies—and that viewpoint has been adopted in the final report of the BEIR Committee.[11] There is even a new collection of evidence that low level radiation may be beneficial.[12] But there has been virtually no journalistic coverage for any of this evidence for a NO answer. The press has devoted far more copy to the Mancuso Study alone than to all the other evidence combined.

Is low-level radiation much more dangerous than indicated by the 1972

studies? The scientific community has answered with a resounding NO, but journalists have given the public the clear impression that the answer is YES.

Effectively then, journalists have taken upon themselves the task of deciding the answer to a strictly scientific question. Not recognizing their own limitations—they have none of the many years of educational and research experience logged by scientists and are not familiar with the many dozens of scientific papers relevant to the question—they have completely reversed the scientific community's decision. And, it is the journalists' decision that the public reads and hears.

Of course, not all questions can be answered with a simple yes or no. Some questions require more complex answers. For example, how dangerous is radiation?

This is a question which scientists have investigated extensively. (Here we ignore any scientific controversy over the question; it would make little difference even if we were to accept the Mancuso-Najarian-Bross viewpoint mentioned earlier.) The public wants, needs, and deserves to be informed of their assessment of the danger. It is up to journalists to transmit that assessment.

How dangerous is radiation?

The adjectives journalists invariably use to describe radiation are "deadly" and "lethal." But, if radiation is so deadly and lethal, where are the dead bodies? Electrocution kills 1,200 Americans each year, but no one talks about "lethal" electricity. Ordinary air pollution kills at least 10,000 Americans each year, but it is only referred to as "deadly" in extremely rare situations when it is far above ordinary levels. In contrast, hundreds of thousands of Americans work with radiation every day, but no one is known or suspected to have been killed by it for the past 15 years. In fact, patients treated with radiation therapy for medical purposes receive the largest exposures to radiation, and in this capacity radiation saves tens of thousands of lives each year. None of those exposed to the "deadly" or "lethal" radiation of journalists' stories receive even 1 percent of the exposure given to these patients.

The inordinate coverage journalists give to accidents involving the release of radiation also creates the wrong impression about the danger radiation presents to public health. For example, the press reported widely on radioactivity leaks from low-level waste burial grounds in western New York and in Kentucky. A Philadelphia newspaper featured a three-part series carrying the headlines "It's Spilling all over U.S.," "Nuclear Grave is Haunting Ky.," and "There's No Hiding Place." Yet, the actual radiation exposure resulting from all these leaks combined is such that there is less than 1 chance in 100,000 that there will some day be a single fatality due to it. Even the potential for damage in these situations is negligible: if all the material buried in these sites were to leak out and become distributed through the ground (or eventually get into rivers) and if this ground then were used for farming to the same extent as average land with the radioactive materials taken up by plant roots into food crops, the total number of eventual fatalities spread over the next million years would be about one—one single fatality.[13] Is this danger consistent with the coverage journalists give it?

Effectively then, journalists have taken upon themselves the task of deciding the answer to a strictly scientific question.

What about the coverage given to incidents in which radioactive material falls off a truck or spills onto a road or leaks out of a storage tank? About 100 such incidents have occurred over the past 35 years, and they are almost always widely reported. Their effect is that there is less than a 1 percent chance that some day 1 person will die as a result of all those accidents combined. Meanwhile, about 35 workers are killed every day in U.S. industrial accidents. Another 6,000 suffer disabling injuries.[14] These accidents seldom receive national coverage, but if a nuclear worker receives an over-exposure to radiation which has less than a 1 percent chance of causing harmful health effects, the incident is often reported nationally.

How imbalanced is the coverage?

Let's ignore the Three Mile Island accident (where the average expected number of eventual fatalities is 0.2) because one could argue that there was a potential for larger effects. In the five years prior to the Three Mile Island accident, the New York Times Information Bank averaged 200 entries per year

on accidents involving radiation, 120 entries per year on motor vehicle accidents, 50 per year on industrial accidents, and 25 per year on accidents involving asphyxiation. The average numbers of fatalities per year from these accidents were 4,500 for asphyxiation, 12,000 per year for industrial accidents, 50,000 per year for motor vehicle accidents, and 0 for accidents involving radiation. There are more entries on radiation-related accidents—which have caused not one single fatality—than there are on all the other accidents combined, even though those accidents have resulted in over 66,000 fatalities each year.

Clearly journalists are giving the public a grossly exaggerated impression of radiation's relative danger.

Clearly journalists are giving the public a grossly exaggerated impression of radiation's relative danger. They could place that hazard in its proper perspective by informing the public that the radiation releases they are writing about usually give exposures of less than 1 percent of our annual exposures from natural background sources or from medical X-rays, but they rarely make this comparison. More often journalists quote a statement from an industry representative or a government bureaucrat (who have low public credibility) stating that the releases are not harmful, or they remind the reader that radiation can cause cancer.

By the magnitude of their coverage and its tone, journalists have given the public a completely distorted impression of the answer to the question, "How dangerous is radiation?" Once again, the message from the scientific community has not been conveyed accurately to the public.

Journalists should ponder the magnitude and significance of those breakdowns in the communications process. They have reported the wrong answer to a strictly scientific yes-or-no question, and they have distorted the answer to a relative question by failing to provide the proper perspective on it. Now the public seems to be on the threshold of rejecting nuclear energy as "too dangerous" to human health. That decision would have annual consequences in the tens of billions of dollars.

With limited access to the public, the scientific community can do little to inform the public of its true assessment of the danger presented by radiation. Journalists themselves must repair these communication breakdowns. Not to do so would be irresponsible, for unrepaired, those breakdowns could well cause our nation much pain and suffering.

Notes

[1] National Academy of Sciences, Committee on Biological Effects of Ionizing Radiation, *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation* (Washington, D.C.: NAS, 1972); and United Nations, Scientific Committee on Effects of Atomic Radiation, *Ionizing Radiation: Sources and Effects* (New York: United Nations, 1972).

[2] National Academy of Sciences, Committee on Biological Effects of Ionizing Radiation, *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation* (Washington, D.C.: NAS, 1980); United Nations, Scientific Committee on Effects of Atomic Radiation, *Sources and Effects of Ionizing Radiation* (United Nations, 1977); International Commission on Radiological Protection, *Recommendation of the International Commission on Radiological Protection*, ICRP Publication No. 26 (New York: Pergamon Press, 1977); and U.S. National Council on Radiation Protection and Measurements, *Influence of Dose and Its Distribution in Time on Dose Response Relationships for Low-LET Radiations*, NCRP Report No. 64 (Washington, D.C.: NCRP, 1980). Recommendations of various national groups such as the U.K. National Radiological Protection Board often are apparent only through the action they do or do not take on the standards for radiation protection over which they have jurisdiction.

[3] T. F. Mancuso, A. Stewart, and G. Kneale, *Health Physics* 33 (1977): 369.

[4] A recent listing of these critiques appeared in *Science*, 26 Feb. 1982, in a letter by B. L. Cohen; G. B. Hutchinson, B. MacMahon, S. Jablon, and C. E. Land, *Health Physics* 37 (1979): 617; E. Gilbert and S. Marks, *Health Physics* 37 (1979): 791; and U.S. General Accounting Office, *Problems in Assessing the Cancer Risk of Low-Level Ionizing Radiation Exposure* 2 vols., Report EMD-81 (Washington, D.C.: GAO, 1981).

[5] I. D. Bross, M. Ball, and S. Falen, *American Journal of Public Health* 69 (1979): 130; and J. D. Boice and C. E. Land, *American Journal of Public Health* 69 (1979): 137.

[6] T. Najarian and T. Colton, *Lancet* 1978-I (1978): 1018.

[7] A. M. Kellerer and H. H. Rossi, *Cancer*, vol. 1, 605. (New York: Plenum Press, 1975).

[8] R. L. Ullrich, M. C. Jernigan, C. E. Cosgrove, L. C. Sutterfield, N. D. Bowles, and J. B. Storer, *Radiation Research* 68 (1976): 115.

[9] E. J. Purrott and E. Reeder, *Mutation Research* 35 (1976): 437; and R. J. DuFrain, L. G. Littlefield, E. E. Joiner, and E. L. Fromer, *Health Physics* 37 (1979): 279.

[10] G. W. Beebe, H. Kato, and C. E. Land, *Mortality Experience of Atomic Bomb Survivors 1950–74*, Radiations Effects Research Foundation Technical Report 1-77 (Hiroshima: RERF, 1978).

[11] National Academy of Sciences, Committee on Biological Effects of Ionizing Radiation, *The Effects on Populations of Exposure to Low Levels of Ionizing Radiation* (Washington, D.C.: NAS, 1980).

[12] T. D. Luckey, *Hormesis with Ionizing Radiation* (Boca Raton: CRC Press, 1980).

[13] B. L. Cohen, *Nuclear Technology* 41 (1978): 381.

[14] U.S. National Safety Council, *Accident Facts*, 1977 (Chicago: NSC, 1977).

Projected Construction Expenditures

The U.S. investor-owned electric utility industry anticipates spending over $165 billion on new plant and equipment during the five-year period 1982–1986, 38.5 percent more than during the previous five-year period. These estimates, which include Allowance for Funds Used During Construction, reflect inflation's expected impact on construction and financing costs. Inflation will significantly offset the effect of construction cutbacks, cancellations, and deferrals reported during the past year.

The projections are based on an industry-wide survey undertaken during the second quarter of this year. Ninety-seven utility companies and systems, representing over 95 percent of the industry's total assets in 1980, provided information. The data were expanded to represent the entire investor-owned electric utility industry.

It is anticipated, given a somewhat improved economic and regulatory environment, that the investor-owned electric utilities will need to go to the financial markets to raise at least $99 billion, or about 60 percent of the total cost of their 1982–1986 construction program. During 1981, 68 percent of its construction expenditures were financed externally.

Construction expenditure forecasts were broken down by type (see Table 1). Of the $165 billion to be expanded during the 1982–1986 period, over $56.5 billion will be spent for nuclear plant facilities and nuclear fuel. The total cost also includes almost $38.4 billion for the construction of the coal-fired installations and over $9.7 billion for construction of facilities utilizing other fuels, including renewable energy resources. The industry anticipates spending over $47.1 billion on transmission and distribution facilities and an additional $13.7 billion for other electric-utility operations, including over $900 million for programs designed for conservation, load management, and end-use efficiency programs.

The industry estimates that it will spend $2.9 billion for converting oil-fired generation facilities to coal-fired facilities and almost $4.4 billion for pol-

. . . electric utilities will need to go to the financial markets to raise at least $99 billion. . . .

Contributed by the staff of Edison Electric Institute

Table 1. Estimated Construction Expenditures of Investor-Owned Electric Utility Industry 1982–1986 (Millions of Current Dollars)

Type of Facility	1982	1983	1984	1985	1986	Total 1982–1986
Electric Generation						
Nuclear Plant	$13,720	$11,610	$ 8,590	$ 7,110	$ 5,550	$ 46,580
Nuclear Fuel	1,390	1,590	2,110	2,560	2,310	9,960
Total Nuclear	15,110	13,200	10,700	9,670	7,860	56,540
Coal	7,860	7,650	8,100	7,350	7,410	38,370
All Other	1,810	1,700	1,870	2,100	2,230	9,710
Total Generation	24,780	22,550	20,670	19,120	17,500	104,620
Transmission & Distribution	7,860	9,380	9,860	9,830	10,190	47,120
All Other (Electric Operations Only)[a]	2,780	2,790	2,820	2,760	2,590	13,740
Total[b]	35,420	34,720	33,350	31,710	30,280	165,480
AFUDC (Allowance For Funds Used During Construction)	5,920	5,550	4,700	4,070	3,750	23,990
Expenditures for Coal Conversion	240	490	740	840	560	2,870
Expenditures for Pollution Control at Existing Facilities	1,240	1,040	890	570	640	4,380

[a]Includes expenditures on programs designed for conservation, load management, and end-use efficiency.
[b]Includes AFUDC and expenditures for coal conversions and pollution control equipment at existing facilties.

lution control equipment and facilities during the five-year period, 1982–1986.

The investor-owned electric utility industry plans to add 124 generating units with a combined capacity of 80,572 megawatts during the 1982–1986 period. An additional 54 units with a total of 38,914 megawatts of capacity will come on line during the next five-year period, 1987–1991. These estimates are based on the latest *EEI Power Survey* data, which reflect scheduled dates of commercial operations as of April 1, 1982. Total expenditures for new plant and equipment (including AFUDC) during that second period are projected at $199 billion.

The investor-owned electric utility industry plans to add 124 generating units with a combined capacity of 80,572 megawatts during the 1982–1986 period.

In projecting these expenditures, the investor-owned electric utilities assumed, on the average, a growth rate in peak demand of 2.7 percent during the 1982–1986 period and 2.6 percent for the 1987–1991 period. They also assumed growth in kilowatt hour sales of 2.9 percent for the first period and 2.2 percent during the second period. The electric utilities responding indicated that they applied, on average, an 8.8 percent construction cost escalation for the 1982–1986 period and an average of 8.3 percent for the five-year period 1987–1991.

First Quarter Gains in Revenues and Income

First quarter 1982 total electric operating revenues of the investor-owned electric utility industry increased 14.8 percent to over $25.2 billion as compared to the almost $22.0 billion reported in the comparable quarter of 1981. During this same period, total electric operating expenses increased by the slightly lower rate of 13.8 percent, enabling the industry to post a 20.2 percent gain in electric utility operating income. Fuel costs, the single largest operating expense item, represented 44.8 percent of total operating expenses. This was down significantly from the 48.8 percent reported a year ago and reflects the lowered costs of some fuels used in the generation of electricity during the first quarter of this year.

Other utility operating income increased 16.5 percent to $594 million, bringing total utility operating income to $5,041 million, up 19.7 percent over the first quarter 1981 figure.

Net income for the quarter came to $4,042 million, a gain of 31.2 percent. After preferred dividend requirements of $605 million, $3,437 million was available for the common stockholders, equivalent to 84 cents per share compared to the 70 cents per share earned in the comparable quarter of 1981, a gain of 20.0 percent. The average number of shares outstanding increased by 13.5 percent compared to the same quarter of last year. Earnings per share for the twelve-month period ending March 31, 1982 were $2.87, up 10.8 percent over the $2.59 reported for the comparable cumulative period ending a year ago.

Earnings improvement resulted from a number of factors: rate increases granted during the past year and reflected in this quarter; colder than normal weather experienced which pushed up residential kilowatt-hour sales 3.3 percent, despite a 0.1 percent decline in total electricity sales to ultimate consumers; a 16.5 percent increase in other utility operating income and other income; and an increase in the Allowance for Funds Used During Construction (AFUDC). In addition, income was increased by $89 million in reported extraordinary items.

AFUDC increased 25.3 percent in the first quarter of 1982 compared to the same quarter of 1981, reflecting a continuing level of construction expenditures. AFUDC was 39.8 percent of net income before preferred dividends, down slightly from the 41.7 percent reported in the first quarter of 1981. Although this shows some improvement in the cash component of earnings, AFUDC is still at a high level. For the twelve-month period ending with the first quarter of 1982, AFUDC represented 44.1 percent of net income before preferred dividends, virtually unchanged from the 44.0 percent one year earlier.

Improved earnings were reflected in the interest coverage ratio for the first quarter of this year, which before income taxes and including AFUDC was 2.85 compared to 2.53 during the same quarter of 1981.

The consolidated income statement given in Table 2 is based on unaudited

reports received from electric utilities. These reports accounted for 93 percent of the industry's revenues. Data were expanded to represent the entire investor-owned electric utility industry.

Table 2. Investor-Owned Electric Utility Industry Statement of Income (Unaudited, Millions of Dollars)

	Three Months Ended			Twelve Months Ended		
	3/31/82	3/31/81	Percent Change	3/31/82	3/31/81	Percent Change
Total Electric Operating Revenues	$25,228	$21,968	14.8	$97,059	$83,514	16.2
Electric Operating Expenses						
Fuel	9,316	8,910	4.6	38,022	33,129	14.8
Other Operation & Maintenance Expenses	5,908	4,844	22.0	21,974	19,086	15.1
Depreciation & Amortization	1,834	1,640	11.8	7,014	6,235	12.5
Taxes Other Than Income Taxes	1,838	1,638	12.2	6,814	6,080	12.1
Income Taxes (Federal & Other)	950	355	167.6	2,726	1,790	52.3
Provisions For Deferred Income Taxes-Net	277	525	−47.2	1,988	1,923	3.4
Investment Tax Credit Adjustments-Net	658	356	84.8	1,529	971	57.5
Total Electric Operating Expenses	20,781	18,268	13.8	80,067	69,214	15.7
Electric Utility Operating Income	4,447	3,700	20.2	16,992	14,300	18.8
Other Utility Operating Income	594	510	16.5	993	914	8.6
Total Utility Operating Income	5,041	4,210	19.7	17,985	15,214	18.2
Other Income and Deductions-Net	465	401	16.0	1,754	1,345	30.4
Allowance for Funds Used During Construction	895	703	27.3	3,269	2,689	21.6
Total Income	6,401	5,314	20.5	23,008	19,248	19.5
Interest On Long-Term Debt	2,783	2,401	15.9	10,587	8,897	19.0
Other Interest Expenses & Charges	379	414	−8.5	1,632	1,457	12.0
Allow. For Borrowed Funds Used in Construction (Cr.)	(714)	(581)	22.9	(2,713)	(2,189)	23.9
Total Interest & Charges	2,448	2,234	9.6	9,506	8,165	16.4
Net Income Before Extraordinary Items	3,953	3,080	28.3	13,502	11,083	21.8
Extraordinary Items	89	—	—	75	—	—
Net Income	4,042	3,080	31.2	13,577	11,083	22.5
Preferred Stock Dividends Declared	605	581	4.1	2,333	2,133	9.4
Net Income Available For Common	$3,437	$2,499	37.5	$11,244	$ 8,950	25.6
Earnings Per Share*	$ .84	$ .70	20.0	$ 2.87	$ 2.59	10.8

Note: The income statement is a "net" or "consolidated" statement, since the duplicative effect of including resale revenues by one investor-owned electric utility to another has been eliminated.

*Based on average shares for the quarter and the twelve months ended.

The Politics of Clean Air: EPA Standards for Coal-Burning Power Plants

Elizabeth H. Haskell
Praeger Publishers, 1982
New York 206 pp.

By Paul Bailey

This was the most controversial and expensive decision ever made by EPA.

The setting is Washington, D.C. The story's major actors include the utility industry, coal interests, Congress, the White House, the Council of Economic Advisors, the Council on Wage and Price Stability, and the Department of Energy.

The Politics of Clean Air tells how the U.S. Environmental Protection Agency decided what emission standards (called "New Source Performance Standards") should be set for future coal-fired power plants. This book is not light reading; rather, it is technical, using plenty of numbers. But, author Elizabeth Haskell does an excellent job of documenting how a very important set of environmental regulations came into being. The author uses this book as teaching material in environmental policy courses at Harvard University.

The story basically begins in the summer of 1977 when Congress passed widely sweeping amendments to the federal Clean Air Act. One of those amendments required that future power plants reduce their emissions, most notably of sulfur dioxide, by an unspecified "percentage." It was left up to EPA to decide what Congress meant by such a requirement, and this is the tale that Ms. Haskell unfolds in her book.

Billions of dollars hung on EPA's decision as to whether or not future coal-fired power plants should be required to install expensive flue-gas scrubbers to control sulfur dioxide emissions. EPA's answer, after almost two and a half years of meetings and studies, was that they should. This was the most controversial and expensive decision ever made by EPA. That decision reflected a mixture of art and science—the art of politics and the science of computer modeling. The utilities and their allies waged a lobbying battle against environmentalists and high-sulfur coal producers. (The latter alliance demonstrates the proverbial strange bedfellows that politics makes—"dirty" coal and "clean" environmentalists both fighting to ensure that scrubbers will be used on all new power plants.) One of the most potent weapons these antagonists used was computer modeling exercises, the results of which showed how their favorite standard was "better" than others being considered.

EPA had a host of factors to consider in reaching its decision: the cost of scrubbers, their technological capability, the effect of its standards on high-sulfur versus low-sulfur coal production, the tons of sulfur dioxide that would be emitted, and how its standards would affect the use of oil by utilities. Before EPA issued its final standards on June 11, 1979, the agency had evaluated 33 alternative standards, testing each to determine how it would affect those factors. Ultimately, EPA had to balance these factors in selecting its New Source Performance Standards. However, to paraphrase an anonymous pundit, balance lies in the eye of the beholder.

The Management of Radioactive Wastes: An Annotated Bibliography

By Patrick J. Wheeler

How much does the public really know about nuclear wastes? Public opinion research indicates that the management of radioactive wastes is a primary impediment to public acceptance of nuclear energy. In survey after survey, a plurality of respondents has cited the wastes issue as its greatest concern about nuclear energy.

To help raise the level of public knowledge on the management of radioactive wastes, the Committee for Energy Awareness (CEA) compiled this annotated bibliography on the subject. The materials selected for inclusion represent some of the best and most current information on a range of subjects: the sources of radioactive wastes and their characteristics; methods for handling, storing, and transporting

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high-level waste; promising options for permanent disposal; and standards to protect the public health and welfare. Entries about the basics of radiation and nuclear power are also included to provide some background for the wastes management issues. A few items of historical and technical interest are noted as well. The CEA, a public information organization funded by the U.S. electric energy industry, compiled the bibliography with the cooperation of various government agencies, civic and service groups, industry organizations, and publishers who agreed to make their materials available.

The information sources are grouped by type of material—books and booklets, brochures and fact sheets, and audio-visuals. Within each grouping, the subject matter is organized in three categories: waste management, radiation, and general references. Each entry is made alphabetically by title. Pertinent information for each entry includes author, publisher, date of publication, length, and a brief abstract of the subject matter covered. The organizations from which copies of most materials may be ordered and costs (if any) are listed. The balance of the entries, particularly articles from popular scientific magazines, may be obtained at local libraries or directly from the publisher. Information sources other than local libraries are listed at the end of the bibliography.

Books and Booklets

Waste Management

1. *Answers to Your Questions About High-Level Nuclear Waste Isolation*
   Office of Nuclear Waste Isolation (ONWI), U.S. DOE, 1981, 70 pp.

   Information about the U.S. Department of Energy's program for isolating highly radioactive nuclear waste. Questions posed are those frequently asked during public meetings and briefings about the government's program plans, the site selection process, the repository, risks and safety, consultation between federal agencies and state governments, environmental and regulatory aspects, and international cooperation. Answers are brief and couched in laymen's terms.

   Distributed by ONWI; no charges.

2. *Fuel/Waste*—Book 2 in the Nuclear Power and the Environment Series
   American Nuclear Society, publication pending June 1982, 30 pp.

   Major topics include nuclear fuel safeguards, transportation, waste management and disposal, and the nuclear fuel cycle. The question/answer format highlights the key facts about each issue. Charts, graphs, and a complete listing of references are provided. Other titles in the series include: Radiation (Book 1), Safety/Risks (Book 3), and Energy Alternatives (Book 4).

   Distributed by the American Nuclear Society; $4 per copy/quantity discounts available.

3. *High Level Radioactive Waste Disposal*
   American Nuclear Society, 1979, 4 pp.

   A policy statement of the American Nuclear Society which expresses concern that the delay in constructing the first federal repository for nuclear waste disposal may impair the authorization of future nuclear power plants.

   Distributed by the ANS; no charge for single copies/$1.50 each for quantity orders.

4. *The Management of Radioactive Wastes*
   International Atomic Energy Agency, 1981, 14 pp.

   An international perspective on waste. The booklet describes the differences between high-, medium-, and low-level radioactive wastes, and how technology today handles high-level wastes. A table indicates the current practices and future plans for waste management in 15 countries, including the United States and the Soviet Union.

   Distributed by the Atomic Industrial Forum, Inc.; 75¢ per copy.

5. *Managing Commercial High Level Radioactive Waste*—Summary Report
   Office of Technology Assessment, U.S. Congress, (OTA-0-172) April 1982, 66 pp.

   A comprehensive analysis of federal policies and programs for handling and disposing of high-level radioactive waste performed by OTA's High Level Waste Project Staff, including outside experts. Problems highlighted include the erosion of public confidence in the feasibility of waste management, the political and institutional framework in which waste management policies are developed, the role of the states in the decision-making process. The major findings suggest that there are no insurmountable technical obstacles to disposing of radioactive wastes in mined geologic repositories, provided suitable sites are found and that the multiple-barrier approach will provide safe, long-term isolation. Focus on the areas of technical disagreement reveal that the ultimate feasibility of the program is not at stake, rather the degree of design conservatism and the pace and scope of R&D programs.

   Distributed by the Public Communications Office, OTA, U.S. Congress; no

Entries about the basics of radiation and nuclear power are also included. . . .

charge for the summary report/copies of the complete technical study available from the Superintendent of Documents, U.S. Government Printing Office.

6. *Nuclear Waste Isolation Activities Report*
Beverly A. Rawles, editor, Office of Nuclear Waste Isolation, U.S. DOE, 1980, 32 pp.

The *Report*, updated and reissued periodically, provides information about the Department of Energy's National Waste Terminal Storage Program to researchers, decision-makers, the general public, and participants in the program itself. It contains current information on such topics as ongoing research, organizational changes, new technological developments, and current literature on nuclear waste management.

Distributed by ONWI; no charges.

7. *Nuclear Waste Management . . . A Manageable Task*
Westinghouse Electric Corporation, 1979, 48 pp.

Information on the status of nuclear waste management technology based on the results of research programs in the U.S. and other countries. Topics include: interim storage, transportation, disposal, hazards, and U.S. programs. A glossary of key terms and acronyms is included in the booklet, along with a complete listing of references. Background information discusses the types and sources of nuclear waste, current inventories, and radioactivity.

Distributed by the Advanced Reactors Division, Westinghouse Electric Corporation; no charges.

8. *Nuclear Waste Management & Recent Accomplishments*
Electric Power Research Institute, (NP-1087) March 1979, 96 pp.

An assessment of the quantities of radioactive waste and spent nuclear fuel is followed by status reports and state-of-the-practice evaluations on such subjects as: reprocessing and fuel refabrication, interim storage of spent fuel and high-level waste, conversion and packaging of wastes for isolation, transportation considerations, waste disposal regulations and criteria, waste repository, and other fuel cycle wastes.

Distributed by the Electric Power Research Institute; $9.50/copy.

9. *A Nuclear Waste Primer*
Marjorie Beane, League of Women Voters Education Fund, 1980, 80 pp.

An elementary survey of the topic of nuclear wastes, including information on types of waste, the nuclear fuel cycle, radiation hazards, and waste management practices—past and present.

Distributed by the League of Women Voters; $1.95 per copy/quantity discounts available.

10. *The Politics of Nuclear Waste*
Edited by E. William Colglazier, Jr., Harvard University, Pergamon Press, 1982, 275 pp.

A cogent and readable examination of the successes and failures of attempts to develop governmental solutions to transportation and siting of nuclear waste facilities, with special emphasis on the conflicts between federal and state policy making.

Distributed by Pergamon Press; $27.50 per hard cover copy.

11. *Radioactive Wastes*
International Atomic Energy Agency, 1978, 50 pp.

Analyzes and explains some of the waste management questions and their relation to the further expansion of nuclear power. Topics include: waste, its treatment, storage, and disposal; the growing public awareness of the need for improved protection of the environment; international waste program plans; and potential risks. The booklet suggests that risks involved in nuclear power and management of its wastes have been overestimated and that they have not been viewed in relation to routinely accepted risks of our society.

Distributed by the Electric Council of New England; single copies only.

12. *Statement of Position of the Atomic Industrial Forum, Inc. on The Storage and Disposal of Nuclear Waste*
Atomic Industrial Forum, Inc., 1980, 30 pp.

The nuclear industry's report prepared for the Waste Confidence Rulemaking of the U.S. Nuclear Regulatory Commission to help assess the degree of assurance we have today that radioactive waste can be disposed of safely, to determine when such disposal or off-site storage will be available, and to determine whether radioactive wastes can be safely stored at the nuclear plant site until off-site storage or disposal is available.

Distributed by the Atomic Industrial Forum, Inc.; no charges.

13. *Understanding Radioactive Waste*
Raymond L. Murray, Battelle Press, 1982, 117 pp.

A readable text book which explains the origin and nature of nuclear by-products; provides facts and figures about nuclear wastes and a perspective on the safety of waste isolation systems. The author tries to distinguish between knowledge and opinion whenever possible in an unbiased and candid manner. This new publication helps the reader understand such nuclear topics as uranium, radioactivity, radiation, and fission, along with the role of materials, chemical processes, and geology in the treatment and long-term handling of wastes.

Distributed by Battelle Press; $10 per copy/quantity discounts available.

Radiation

14. *How Concerned Should We Be About Low-Level Radiation?*
International Atomic Energy Agency, 1980, 19 pp.

A companion booklet to "Radiation—A Fact of Life." The basis of radiation protection, the claims and rebuttals about the dangers of low-level radiation, and perspectives on risk are presented. The booklet contains a brief summary of studies which claim that low-level radiation risks have been underestimated, then discusses why these findings are believed to be in error.

Distributed by the American Nuclear Society; 50¢ per copy.

15. *Radiation*
L. Ferson, Westinghouse Electric Corporation, 1979, 12 pp.

Fundamentals of radiation, where it originates, and how it affects all of us. The information puts concerns about radiation associated with nuclear energy in perspective as an aid in weighing the risks and benefits of nuclear energy. A workbook-style sheet is included so that the reader can compute his own radiation dose.

Distributed by Nuclear Energy Systems, Westinghouse Electric Corporation; no charges.

16. *Radiation*—Book 1 in the Nuclear Power and the Environment Series
American Nuclear Society, 1980, 24 pp.

Major topics include sources of radiation, radioactivity from the nuclear fuel cycle, the biological effects of radiation, and plutonium toxicity. Information is presented in question/answer format followed by references. Other titles in the series include: Fuel/Waste (Book 2), Safety/Risks (Book 3), and Energy Alternatives (Book 4).

Distributed by the American Nuclear Society; $4 per copy/quantity discounts available.

17. *Radiation—A Fact of Life*
International Atomic Energy Agency, 1981, 14 pp.

Sources of background and man-made radiation, types of radiation, radiation dose, the evolution of radiation protection, benefits of radiation, and comparative risks of radiation are discussed. The work of the IAEA is mentioned, and a bibliography of technical reports on low-level radiation is included.

Distributed by the American Nuclear Society; 50¢ per copy.

18. *Radiation and Life*
Eric J. Hall, Columbia University, Pergamon Press, 1976, 200 pp.

Dr. Hall, a professor of radiology at the College of Physicians and Surgeons, Columbia University, explores the physiological effects of radiation and radiation safety measures. He also recounts the uses of atomic energy, including medical radiology and nuclear power, followed by a discussion of the risks and benefits of harnessing the atom.

Distributed by Pergamon Press; $27 per copy.

General

19. *12 Questions About Nuclear Power, With Answers*
K. D. Kearns, PhD, Energy Research Group, Committee for Energy Awareness, 1981, 32 pp.

The 12 most frequently asked questions about nuclear power—need for nuclear power, radiation, power plant safety, economics, waste disposal, the opposition, utility building programs, human errors, credibility of industry spokespersons, societal impacts, risks and benefits to a local community, comparison with conservation and renewable energy sources—and answers used by experienced spokespersons. Corroborating studies and statements are cited after each answer.

Distributed by the Committee for Energy Awareness; no charge for quantities of 25 or less/75¢ for each additional copy.

20. *Nuclear Energy Glossary*
Lois Ferson, editor, Westinghouse Electric Corporation, 1979, 20 pp.

Defines 66 of the commonly-used nuclear terms that laymen will need to discuss and understand the generation of electricity from nuclear power. Each definition is accompanied by an illustration. The layout of a nuclear power plant and its key systems and components are featured.

Distributed by Nuclear Energy Systems, Westinghouse Electric Corporation; no charges.

21. *Nuclear Power*
R. W. Deutsch, General Physics Corporation, 1979, 42 pp.

A readable text for grade school and junior high school students about the basics of nuclear power.

Distributed by General Physics Corporation; $1.50 per copy.

22. *A Nuclear Power Primer: Issues for Citizens*
Marjorie Beane, League of Women Voters Education Fund, 1982, 80 pp.

The primer contains information about nuclear power plants, the nuclear fuel cycle, and the complex issues surrounding them, including the economics of energy alternatives, the current status of waste disposal facilities, and nuclear nonproliferation. It also contains a brief history of nuclear power and outlines the policy options for the future.

Distributed by the League of Women Voters; $2.50 per copy/quantity discounts

available for League members and nonmembers.

23. *Questions Kids Ask About Energy*
Westinghouse Electric Corporation, 1981, 43 pp.

A question-answer format is used to discuss topics like the energy crisis, electricity, fusion, coal, synthetic fuels, solar power, and nuclear power. Nuclear waste is discussed briefly in the context of the development of nuclear power, nuclear safety, radiation, and Three Mile Island. The booklet is illustrated by fifth and sixth grade students from Pennsylvania; the questions evolved from discussions with students in the Pittsburgh area.

Distributed by the Advanced Reactor Division, Westinghouse Electric Corporation; no charge for quantities of 250 or less/43¢ plus postage for each additional copy.

Articles, Brochures, Fact Sheets, and Reprints

Waste Management

24. "Answers to Your Questions About High Level Nuclear Waste Isolation"
Office of Nuclear Waste Isolation, U.S. DOE, 1981, 69 pp.

Topics include highlights of the federal waste management program and information on: site selection, the repository, risks and safety, federal/state consultation, environmental and regulatory aspects, and international cooperation.

Distributed by the ONWI Library; no charges.

25. "Burying Nuclear Trash Where It Will Stay Put"
Edmund Faltermayer, *Fortune*, March 26, 1979.

A discussion of the relationship of spent fuel and wastes, the possible geologic media for waste disposal, and the political aspects of waste disposal.

Available in local libraries.

26. "Containing Nuclear Waste"
Petr Beckmann, *Reason*, September 1981, 8 pp.

A comparison of the risks and benefits of waste handling and disposal for various energy sources, including nuclear, coal, and solar technologies. Waste management programs in France, Germany, and Japan are described.

Reprints distributed by the Atomic Industrial Forum, Inc.; no charge for single copies.

27. "The Disposal of Radioactive Wastes from Fission Reactors"
Bernard L. Cohen, *Scientific American*, June 1977, p. 21 ff.

A substantial body of evidence suggests that the high-level wastes generated by U.S. nuclear power plants can be stored satisfactorily in deep geologic formations.

Available in local libraries.

28. "Everything You Always Wanted to Know About Shipping High-Level Nuclear Wastes"
Office of Nuclear Waste Isolation, U.S. DOE, 1978, 53 pp.

The 69 "most often asked" questions about transporting nuclear wastes and detailed answers intended for general audiences. Photographs and diagrams are included.

Distributed by the ONWI Library; no charges.

29. "Fact Sheet Series About Nuclear Waste Management"
Office of Nuclear Waste Isolation, U.S. DOE, 1981, 1 page each.

"Can Nuclear Wastes Be Isolated Beneath the Oceans?"
"Can Nuclear Wastes Be Launched into Space?"
"Can Nuclear Wastes Be Transported Safely?"
"How Much Waste Is There from Nuclear Power Production?"
"What Are the Waste Products of a Nuclear Reaction?"
"What Is 'Spent' Nuclear Fuel?"
"What Might a Nuclear Waste Repository Look Like?"

Distributed by ONWI; no charges.

30. "Here's How U.S. Seeks Waste Sites"
Walter E. Newcomb, *Geotimes*, December 1980, 3 pp.

The concept of mined geologic repositories for isolating high level radioactive waste safely is explored. Field explorations on federal reservations on the Nevada test site, the Hanford basalt site, the Gulf Coast salt dome basins, salt troughs in Utah and southwestern Colorado (the Paradox Basin), and the Permian Basin in parts of western Kansas, eastern Colorado, Oklahoma, Texas, and New Mexico are described. The results of site investigations to date are given, based on reports by subcontractors to the U.S. Department of Energy.

Reprints distributed by ONWI Library; no charges.

31. "High-Level and Long-Lived Waste Disposal"
Ernest E. Angino, *Science*, December 1977, p. 885.

An international approach to the solution of the waste problem in view of the worldwide adoption of nuclear power. The article contains information about the rock factors to be considered, the variety of disposal methods, thermal effects, and seismic matters. References are included.

Available in local libraries.

32. "How Can We Safely Dispose of Nuclear Waste?"
American Nuclear Society, 1981, 1 index card.

A card containing a scale size glass marble, with information on the waste barriers for storing solidified radioactive wastes.

Distributed by the American Nuclear Society; 32¢ per card.

33. "How to Find Information on Nuclear Waste Isolation"
Office of Nuclear Waste Isolation, U.S. DOE, 1981, 8 panel leaflet.

ONWI is responsible, under government contract, for making information on nuclear waste isolation available to the public. The brochure describes their library holdings, information services and computerized data bases.

Distributed by ONWI; no charges.

34. "An Interview with Dr. Cohen: Q-and-A on Waste"
Nuclear Industry, January 1981, 4 pp.

Dr. Bernard L. Cohen, a physicist at the University of Pittsburgh, was interviewed about the safety of waste disposal and refutes the "myths" about waste disposal identified previously by Dr. Marvin Resnikoff of the Sierra Club Radioactive Waste Campaign.

Reprints distributed by the Atomic Industrial Forum, Inc.; no charges.

35. "Leachability of Radioactive Solids"
Special Issue, *Nuclear and Chemical Waste Management*, A. Alan Moghissi, editor-in-chief, February 1981, 170 pp.

More than 33 authors contributed state-of-the-art reports to this special issue devoted to leachability.

Available in local libraries.

36. "Managing Nuclear Waste"
Atomic Industrial Forum, Inc., 1976, 8 panel leaflet.

A step-by-step description of reprocessing, waste handling, and disposal. The brochure features an illustration of a waste disposal facility in a salt formation.

Distributed by the Atomic Industrial Forum, Inc.; no charge for single copies/ quantity discounts available.

37. "National Energy Statement—Nuclear Waste Disposal"
American Association of Engineering Societies, June 1980, 8 pp.

A policy statement that addresses the issue of radioactive waste, maintaining that existing technologies, solidification for example, have demonstrated that nuclear waste can be isolated safely.

Distributed by the Coordinating Committee on Energy; no charges.

38. "A Natural Fission Reactor"
George A. Cowan, *Scientific American*, July 1976, p. 36 ff.

Two billion years ago in West Africa a rich deposit of uranium ore began operating as a nuclear reactor. Long dormant but preserved intact, the reactor came to light during the mining of the deposit. This article traces the history of this natural reactor at Oklo in the Gabon Republic—an extraordinary sequence of seemingly improbable events. This natural reactor produced the equivalent waste of a full-size nuclear power reactor operating for one year. Thus its successful retention of these wastes made in boiling water deep underground is an illuminating precedent for deep geologic disposal of nuclear power reactor waste.

Available in local libraries.

39. "Nuclear Waste Disposal"
Westinghouse Electric Corporation, 1979, 2 pp.

The volume of high-level nuclear waste is compared with waste from other fuels, followed by a discussion of nuclear waste hazards, what is being done with spent fuel today, and the long-term methods for disposing of high-level wastes (solidification and deep underground burial).

Distributed by the Energy Action Office, Westinghouse Electric Corporation; no charges.

40. "Nuclear Waste Disposal: Not in My Backyard"
Alan Jakimo and Irvin C. Bupp, *Technology Review*, March-April 1978, p. 64.

An investigation of the public's perception of nuclear wastes, the history of fuel reprocessing, and the storage of spent fuel in water pools. Methods of disposal are outlined in the article and the existence of a political problem is noted.

Available in local libraries.

41. "Nuclear Waste/Nuclear Power—Their Futures Are Linked"
L. T. Skoblar, Envirosphere Company, a Division of Ebasco Services Incorporated, 1981, 11 pp.

A paper presented at the Fifty-Second Annual Utility Executive Conference which reviews the status of four waste issues—high-level waste disposal, away-from-reactor storage, low-level waste disposal, and transportation—in light of their impact on utility plans, operations, and costs. For each issue, the responsibilities of federal and state agencies, the status of their respective efforts, and specific issues of interest to utilities are discussed.

Reprints distributed by the Atomic Industrial Forum, Inc.; no charges.

42. "Nuclear Wastes: Where Do They Go?"
William G. Reinhardt, *Sciquest*, May/June 1980, 5 pp.

The political and scientific issues surrounding waste management decisions are updated from a public acceptance viewpoint.

Reprints distributed by Atomic Industrial Forum, Inc.; no charge for single copies.

43. "Report to the American Physical Society by the Study Group on Nuclear Fuel Cycle and Waste Management"
American Physical Society, *Reviews of Modern Physics*, January 1978, special supplement.

A thorough technical assessment of the national issue of using nuclear fuels and the management of nuclear wastes. The principal economic, environmental, and health and safety implications of waste management are considered.

Available in local libraries.

44. "The Safety of Repositories for Highly Radioactive Wastes"
Charles M. Koplik, Maureen F. Kaplan, and Benjamin Ross, The Analytic Sciences Corporation, *Reviews of Modern Physics*, January 1982, p. 269 ff.

Many authors have studied the safety of disposal of highly radioactive wastes in excavated cavities beneath the earth. Work has been concentrated in three areas: prediction of future events and processes which could affect waste containment, mathematical modeling of failure scenarios, and estimation of uncertainties in model predictions. The results of past safety assessments are reviewed and compared: anything but a very small release of radioactivity from a repository would appear to be quite unlikely; a quantitative evaluation of the probabilities of small releases has not proved possible.

Available in local libraries.

45. "The Search for Safe Nuclear-Waste Disposal"
Robert B. Aronson, *Machine Design*, February 21, 1980, 5 pp.

An accounting of the steps in waste isolation—reducing the volume of waste, containing it safely, and storing it in repositories for an indefinite period of time without endangering people or the environment. The federal government's Office of Nuclear Waste Isolation Program is featured.

Distributed by ONWI; no charges.

46. "Spent Fuel Management"
Citizens for Adequate Energy, 1981, 4 pp.

A compilation by a grassroots citizen organization about spent fuel, how high-level wastes are generated, and alternative methods for dealing with spent fuel (including reprocessing).

Distributed by Citizens for Adequate Energy; no charge for single copies.

47. "Transportation of Nuclear Materials"
Westinghouse Electric Corporation, 1981, 2 pp.

Shipments of radioactive materials are discussed in the context of hazardous materials and other commodities shipments nationwide; then the transportation process for each step in the fuel cycle is summarized. Cask design criteria and safety precautions required by regulation are listed.

Distributed by the Issue Analysis & Management Department, Westinghouse Electric Corporation; 3¢ per copy.

48. "U.S. Ready to Decide Best Disposal of Nuclear Waste"
Lee Dembart, *The Los Angeles Times*, July 13, 1981, 3 pp.

A review of the contending technologies for preparing nuclear wastes in a form suitable for long-term or permanent disposal.

Reprint distributed by the Atomic Industrial Forum, Inc.; no charges.

Radiation

49. "Radiation"
Westinghouse Electric Corporation, 1979, 2 pp.

What is known about radiation, including levels of background radiation, the effects of radiation, major radiation studies performed, genetic effects, and the current state of knowledge about low radiation doses over long periods of time. Nuclear power plant emissions are then compared to other sources of radiation.

Distributed by the Energy Action Office, Westinghouse Electric Corporation; no charges.

50. "Personal Radiation Dose Chart"
American Nuclear Society, 1980, 2 panel flyer.

The annual radiation dose to which we are subjected depends on where and how we live, and what we eat, drink, and breathe. This easy-to-use chart shows how to estimate that dose and compare it with the amount of exposure found within the vicinity of a nuclear power plant. Suitable for student groups, discussion groups, and exhibitions.

Distributed by the American Nuclear Society; 15¢ per copy/quantity discounts available.

General

51. "Nuclear Power Quick Reference III"
General Electric Corporation, 1981, 68 pp.

A ready reference to a broad spectrum of authoritative information on nuclear power which has been compiled from many sources and organized to enable the user to quickly locate key facts and statistics related to a particular issue. Spent fuel storage, transportation, and

reprocessing, as well as waste disposal, are two of the thirteen subjects treated.

Distributed by the Nuclear Energy Group, General Electric Corporation; no charges.

52. "The Safety of Fission Reactors"
Harold W. Lewis, *Scientific American*, March 1980, p. 53 ff.

By most standards, nuclear reactors are quite safe. The accident at Three Mile Island nonetheless confirmed that decisions about their future call for greater reliance on quantitative methods of assessing risks presented by such systems.

Available in local libraries.

Audio-Visuals

Waste Management

53. *Accident Testing*
Sandia Laboratories, 1980, 16mm film in two lengths—12 minutes and 3 minutes, color.

High speed crash-tests and other tests of containers used in shipping high-level nuclear wastes are illustrated in the 3-minute film. The longer version explains the careful analysis as well.

Distributed by Transportation Technology Center, Sandia Laboratories; no charge for rentals.

54. *Basalt Waste Isolation Project*
Basalt Waste Isolation Project, Rockwell Hanford Operations, 1980, ¾" videotape in two lengths—23 minutes or 8½ minutes.

A progress report on the study of potential waste repository sites at the Hanford Reservation in Washington state.

Distributed by Basalt Waste Isolation Project; no charge for rentals.

55. *The Challenge of Nuclear Waste Isolation*
U.S. DOE, 1981 revised, 2-projector cued slide presentation, 19 minutes.

Background and overview of the sources and types of nuclear wastes produced in this country, and the U.S. DOE's National Waste Terminal Storage program to find sites and technologies for isolating high-level commercial nuclear wastes.

Distributed by Battelle Project Management Division; no charge for rentals.

56. *A Factual Basis for Nuclear Waste in Disposal*
Science Software Systems, Inc., available after May 1982, 2-projector cued slide presentation, 25 minutes.

A review of the various technical alternatives for disposing of high-level radioactive waste, focussing on deep geologic disposal and the relative toxicity of wastes.

Distributed by Science Software Systems, Inc.; prints are $75.

57. *Here Today, Here Tomorrow, Radioactive Waste in America"*
KPBS-TV San Diego State University, 1980, ¾" videotape, 28 minutes, color.

A documentary about current nuclear waste problems and disposal activities which includes interviews with supporters and opponents of nuclear power. The videotape was produced for Pacific Coast public broadcasting stations, with additional support from the National Science Foundation's Public Understanding of Science Program.

Distributed by KPBS-TV, San Diego State University; no charge for rental.

58. *Nuclear Waste Fuel Management*
Atomic Energy of Canada, Ltd., 1979, 16mm film, 22 minutes 40 seconds, color.

The Canadian nuclear waste isolation program is broadly described with highlights of research being done at the Whiteshell facility.

Distributed by Waste Management Public Affairs, Atomic Energy of Canada, Ltd.; no charge for rentals.

59. *Nuclear Waste Isolation: A Progress Report*
U.S. Department of Energy, 1981, 16mm film, color.

A progress report on what has been accomplished and what is currently being done by the U.S. DOE to find a safe disposal system for highly radioactive commercial waste. Live interviews at various field sites, nuclear facilities, and research laboratories across the country are featured, along with animation of the nuclear fission process. Sources of radioactive wastes, the types and levels of radiation they emit, and temporary storage methods are described.

Distributed by Modern Talking Picture Service; no charge for rentals.

60. *Nuclear Waste—Where Do We Stand*
Committee for Energy Awareness, available after August 1, 1982, ¾" videotape, 28 minutes, color.

This public affairs program deals with the technology and the people responsible for the safe handling, transportation, and disposal of radioactive waste. It is divided into three segments: Part I: Where the nuclear waste is generated—medicine, power plants, research, the military. Part II: What is done with it— packaging, transportation, and storage. Part III: Radiation, benefits vs. risk, comparison to other wastes, impact on the environment.

Distributed by the Committee for Energy Awareness; prints are $80.

61. *Safety by Underground Storage*
G.S.F., 1980, ¾" videotape, 22 minutes, color.

Documentary about the nuclear waste isolation project at the Asse salt mine in

Germany. Transcribed from film which used a magnetic sound system.

Distributed by Battelle Project Management Division; no charge for rentals.

62. *Spent Fuel Storage and Transportation*
Allied-General Nuclear Services, 1980, ¾" videotape, 38 minutes, color.

Various spent fuel shipping casks and the steps in cask handling and unloading are depicted.

Distributed by Allied-General Nuclear Services; no charge for rentals.

63. *Spent Fuel Storage in Granite*
Lawrence Livermore Laboratory, 1980, 16mm film, color.

This film about the Climax Spent Fuel Test Facility—constructed 1400 feet underground in a granite formation at the Nevada test site—features animation of the repository construction and fuel emplacement process.

Distributed by Waste Isolation Projects, Lawrence Livermore Laboratory; no charge for rentals.

64. *Spent Nuclear Fuel*
Sandia Laboratories, 1981, 16mm film, 12 minutes, color.

The handling and transportation of spent fuel are traced from the reactor to on-site or away from reactor storage pools, with the safety precautions and procedures observed.

Distributed by Transportation Technology Center, Sandia Laboratories; no charge for rentals.

65. *Waste Isolation Pilot Plant*
WIPP Project Office, ¾" videotape, 20 minutes, color.

The early stages of shaft construction and future plans for the Waste Isolation Pilot Plant project near Carlsbad, New Mexico are described.

Distributed by WIPP Project Office; no charge for rentals.

66. *TV Commercials—Waste Management & Radiation*
Committee for Energy Awareness, Available after July 1, 1982, ¾" videotape, 1 30-seconds, 1 60-seconds, color.

The technology exists to solve the problem of radioactive waste. The method, endorsed by the National Academy of Sciences, is to permanently seal off the waste from our environment and store it deep in stable geologic formations. Fifteen nations worldwide are involved in developing this technology.

Distributed by the Committee for Energy Awareness; prints are $40, which includes two 30-second CEA TV commercials on low-level radiation.

Radiation

67. *Radiation . . . Naturally*
Atomic Industrial Forum, Inc., 1981, 16mm film or ¾" and ½" videocassette, 28½ minutes, color.

Viewers are taken through the basics—radiation sources, applications, effects, benefits, and risks—dispelling many of the popular myths and supplying the correct information where misinformation abounds. With the help of intricately drawn animation, the film explores radiation sources—from the far reaches of deep space to the inside of the atom. A comprehensive package of collateral materials accompanies the film, including a film user's guide, adult and student activities, discussion and factual questions, glossary, and background information.

Distributed by Audio-Visual Office, Atomic Industrial Forum, Inc.; member's price $275/inquire about previews, educational discounts, quantity orders, and non-member prices.

Index to Information Sources

These organizations distribute the materials listed in the bibliography. The numbers in parentheses ( ) correspond to the citation.

Allied-General Nuclear Services
Post Office Box 847
Barnwell, South Carolina 29812
(62)

American Nuclear Society
555 North Kensington Avenue
LaGrange, Illinois 60525
(2, 3, 14, 16, 17, 32, 50)

Atomic Energy of Canada, Ltd.
Waste Management of Public Affairs
Whiteshell Nuclear Research Establishment
Pinawa, Manitoba R0E 1L0 Canada
(58)

Atomic Industrial Forum, Inc.
Publications Office
7101 Wisconsin Avenue
Bethesda, Maryland 20014
(4, 12, 26, 34, 41, 42, 48, 67)

Basalt Waste Isolation Project
Public Affairs
Rockwell Hanford Operations
Post Office Box 800
Richland, Washington 99352
(54)

Battelle Press
505 King Avenue
Columbus, Ohio 43201
(13)

Citizens for Adequate Energy
333 Kearney Street
San Francisco, California 94108
(46)

Committee for Energy Awareness
Suite 609
1111 Nineteenth Street, N.W.
Washington, D.C. 20036
(19, 60, 66)

Coordinating Committee on Energy
345 East 47th Street

New York, New York 10017
(37)

Electric Council of New England
54 Middlesex Turnpike
Bedford, Massachusetts 01730
(11)

Electric Power Research Institute
Publications Office
Post Office Box 50490
Palo Alto, California 94303
(8)

General Electric Corporation
Nuclear Power Group
175 Curtner Avenue
San Jose, California 95125
(51)

General Physics Corporation
1000 Century Plaza
Columbia, Maryland 21044
(21)

KPBS-TV
San Diego State University
San Diego, California 92182
(57)

Lawrence Livermore Laboratory
Waste Isolation Projects
University of California
Post Office Box 808
Livermore, California 94550
(63)

League of Women Voters
1730 M Street, N.W.
Washington, D.C. 20036
(9, 22)

Modern Talking Picture Service
5000 Park Street North
St. Petersburg, Florida 33709
(59)

Office of Nuclear Waste Isolation
(ONWI/Library)
Project Management Division
Battelle Memorial Institute
505 King Avenue
Columbus, Ohio 43201
(1, 6, 24, 28, 29, 30, 33, 45, 55, 61)

Office of Technology Assessment
Public Communications Office
U.S. Congress
Washington, D.C. 20510
(5)

Pergamon Press, Inc.
Maxwell House
Fairview Park
Elmsford, New York 10523
(10, 18)

Science Software Systems, Inc.
11899 West Pico Boulevard
West Los Angeles, California 90064
(56)

Transportation Technology Center
Sandia Laboratories
Albuquerque, New Mexico 87906
(53, 64)

Westinghouse Electric Corporation
Advanced Reactors Division
Post Office Box 158
Madison, Pennsylvania 15663
(7, 23)

Westinghouse Electric Corporation
(All other divisions)
Post Office Box 355
Pittsburgh, Pennsylvania 15320
(15, 20, 39, 47, 49)

WIPP Project Office
Post Office Box 30039
Albuquerque, New Mexico 87906
(65)

. . . we could see the ample reserve margins of today reduced to dangerously low levels. . . .

Continued Reductions in Planned New Capacity

Since 1975, there has been a continuous erosion in the total amount of new generating capacity planned by the electric utility industry. The total scheduled backlog of future installations (expansion program) had reached a record level of over 310 gigawatts by the end of 1974. As can be seen from Table 1, the decline in the expansion program from 300 gigawatts in 1975 to 170 gigawatts at the end of 1981 was a function of two factors: removals of planned projects from the schedule, and the fact that the amount of capacity installed during each of the years exceeded the new capacity ordered.

The reductions in planned new capacity have been made largely in response to successive decreases in the industry's annual long-term projections of peak demand growth compiled each spring by the North American Electric Reliability Council—from a ten-year projection of 7.6 percent in 1974 to 3.0 percent in 1982. These reductions in projected electricity growth rates, in turn, can be attributed to the cumulative experience of less than expected growth in electric demand for several years in a row, increased utilization of load management and conservation techniques, and a decline in projected economic activity.

The 10 to 12 years it takes between planning a new generating unit and putting it into service has meant that the successive decreases in long-term demand projections have caused the postponement and even cancellation of many generating units placed in the schedule during earlier periods of higher load growth expectations. In addition, an appreciable amount of new capacity has been cancelled or deferred because of the financial constraints faced by the electric utility industry. During 1981 alone, 26 steam turbine-generators totaling 28,104 megawatts were removed from the planning schedule and 54 units aggregating 43,563 megawatts were delayed one year or more.

There is a danger that the pendulum of long-term growth projections has already swung too far toward the negative. Many companies, principally because of low earnings, lack the financial ability to build new plants to replace old generating units as they wear out, much less build new plants in anticipation of future load growth. The long lead times required to bring new generation resources into service mean that if economic recovery or prolonged hot or cold weather should cause large increases in electricity use, we could see the ample reserve margins of today reduced to dangerously low levels before enough new generating plants could be made available.

Contributed by the staff of Edison Electric Institute

Table 1. Orders, Removals from Schedule, Installations, and Year-End Backlog, U.S. Electric Power Systems, Megawatts By Prime Mover, 1975–1981

Year	Prime Mover	MW Ordered	MW Removed	MW Installed	Year-End Scheduled Backlog
1975	Fossil STG's*	5,989	1,897	20,895	122,438
	Nuclear STG's*	6,213	11,051	7,396	157,662
	Comb. Turbs.**	4,259		3,917	6,012
	Hydro	1,458		2,232	13,535
	Total	17,919		34,440	299,647
1976	Fossil STG's	6,786	4,406	11,685	111,003
	Nuclear STG's	8,465	2,414	4,822	162,122
	Comb. Turbs.	1,620		2,285	6,488
	Hydro	2,961		1,629	14,796
	Total	19,831		20,421	294,409
1977	Fossil STG's	13,602	1,696	18,072	102,538
	Nuclear STG's	—	7,913	6,609	147,442
	Comb. Turbs.	1,240		1,713	5,649
	Hydro	1,596		1,131	15,227
	Total	16,438		27,525	270,856
1978	Fossil STG's	18,333	1,183	13,971	103,256
	Nuclear STG's	—	7,242	3,029	137,169
	Comb. Turbs.	673		1,671	3,380
	Hydro	1,099		4,058	12,352
	Total	20,105		22,729	256,157
1979	Fossil STG's	4,479	2,122	12,332	98,996
	Nuclear STG's	—	14,168	1,156	116,038
	Comb. Turbs.	429		773	2,605
	Hydro	969		2,934	8,839
	Total	5,877		17,195	226,478
1980	Fossil STG's	2,846	3,902	18,709	83,005
	Nuclear STG's	—	10,587	1,885	109,383
	Comb. Turbs.	551		510	2,485
	Hydro	15		1,302	7,708
	Total	3,412		22,406	202,581
1981	Fossil STG's	7,920	3,511	9,777	81,177
	Nuclear STG's	—	24,593	4,427	79,682
	Comb. Turbs.	525		714	1,437
	Hydro	209		259	7,694
	Total	8,654		15,177	169,990

*Steam Turbine-Generators
**Combustion Turbines
SOURCE: *EEI Electric Power Survey* data

Regulatory Overlap in Environmental Licensing

In response to an executive order by President Reagan, the federal government currently is reassessing the impact of federal regulations on the private sector. The executive order, the first step toward a national program of regulatory reform designed to enhance the efficiency of regulatory programs, required the President's Task Force on Regulatory Relief (Task Force) to review several regulatory programs. In turn, the Task Force asked the Environmental Protection Agency (EPA) to reassess its entire consolidated permitting program, the environmental quality protection policies created under the National Environmental Policy Act of 1969 (NEPA), and related authorities such as the Historic Preservation Act. It also asked the Army Corps of Engineers to review its program implementing section 404 of the Clean Water Act for issuing dredge and fill permits and requested that the Department of the Interior review its programs under the Fish and Wildlife Coordination and the Endangered Species Acts.

Eliminating such duplication during the EIS review could prevent delay in the regulatory process. . . .

The potential exists to simplify the environmental licensing process without detracting from the goals of environmental programs.

EPA's environmental programs especially affect the siting, design, construction, and operation of coal-fired electric generating units. No major construction activities on a new unit can commence until an environmental impact statement (EIS) is prepared by a lead agency such as the EPA; thus, the impacts of environmental legislation are crucial.

Other federal laws and resulting regulatory programs control a coal-fired unit's discharges to the environment. These laws include the Clean Air Act, the Clean Water Act, the Resource Conservation and Recovery Act, the Endangered Species Act, the Fish and Wildlife Coordination Act, the Wild and Scenic Rivers Act, the National Historic Preservation Act, the Archeological Resources Protection Act, and the Coastal Zone Management Act. However, some of this legislation duplicates reviews required in an EIS. Eliminating such duplication during the EIS review could prevent delay in the regulatory process by consolidating and coordinating reviews under the various regulatory programs.

An EIS consists of several chapters prepared by or for a federal agency. The National Environmental Policy Act of 1969 (NEPA) lists the requirements that must be satisfied in an EIS, stating that all agencies of the federal government shall:

> Include in every recommendation or report on proposals for legislation and other major Federal actions significantly affecting the quality of the human environment, a detailed statement . . . on (i) the environmental impact of the proposed action, (ii) any adverse environmental effects which cannot be avoided should the proposal be implemented, (iii) alternatives to the proposed action, (iv) the relationship between local and short-term uses of man's environment and the maintenance and enhancement of long-term productivity, and (v) any irreversible and irretrievable commitments of resources which would be involved if the proposed action should be implemented.

The Council on Environmental Quality (CEQ) promulgated regulations in 1978 which required virtually all federal agency regulations to conform to CEQ's regulations, which require that a standard EIS format be used. The heart of this format is the presentation of a proposed project, of alternatives to the proposed project, and of the environmental impacts of the proposal and the alternatives. For proposed power plant projects these alternatives include alternative fuels, plant systems, and plant sites. EIS's for power plants also must consider the environmental impacts of associated transmission systems and indirect impacts such as those of coal mining, processing, and transport. Both EPA and the Corps of Engineers (Corps) have promulgated rules that conform with CEQ's NEPA regulations.

However, when an EIS is prepared according to an appropriate agency's NEPA regulations, contemporaneous environmental reviews also are occuring as a result of other regulatory

Contributed by Peter C. Richie, Manager of Regulatory Affairs, Envirosphere Company

programs. For example, an EIS must specify a project's direct and indirect effects on the environment and any means to mitigate adverse environmental impacts. In addition to this EIS requirement, other regulatory programs require a review of the effects of a project on the environment as well as of mitigating measures. Other laws also impose these requirements:

- The Endangered Species Act can require that a biological assessment be conducted to determine whether an endangered species is

Table 1. A Comparison of Army Corps of Engineers Environmental Impact Statement Requirements with Other Statutory Environmental Reviews

Statute Requirements By Section	Corps' EIS Requirements: Discussion of Beneficial/Adverse Impacts of Project	Discussion of Purpose & Need of Project	Discussion of Alternatives to Project	Discussion of the Affected Environment	Discussion of Environmental Consequences of the Project
CLEAN AIR ACT (CAA) (42 USC 7401 et. seq.)					
Sec. 7475 [165] PSD Permit	x	x	x	x	
Sec. 7479 [169] BACT Analysis*	x	x	x	x	
Sec. 7491 [169a] BART Analysis**	x	x	x	x	
Sec. 7501 [171] LAER Analysis***	x		x		
Sec. 7503 [713] NA Permit****	x			x	
CLEAN WATER ACT (CWA) (33 USC 1251 et. seq.)					
Sec. 1311 [301] Variances From Limitation	x	x	x	x	
Sec. 1317 [307] Pretreatment Study	x				
Sec. 1326 [316] Thermal Variance/Intake Structure Demonstration	x			x	
Sec. 1328 [318] Aquaculture Projects	x	x	x	x	
Sec. 1341 [401] State Certification for Compliance	x	x		x	
Sec. 1342 [402] NPDES Permit	x	x	x	x	
Sec. 1344 [404] Dredged/ Fill Permit	x			x	x
Sec. 1345 [405] Sewage Sludge Disposal Permit	x			x	
ENDANGERED SPECIES ACT (ESA) (16 USC 1532 et. seq.)					
Sec. 1536 Endangered Species Demonstration	x	x	x	x	

*A "BACT Analysis" is an analysis that any major source or major modification subject to PSD must conduct to ensure application of best available control technology (BACT). Evaluated are energy, environmental, economic, and other costs associated with each alternative technology, and the benefit of reduced emissions that each technology would bring.

**In States with pristine air areas (e.g., where national parks are located), major stationary sources which existed on 8/7/77 and which have been in operation 15 years or less to install "best available retrofit technology (BART)".

***In areas with dirty air (i.e., nonattainment areas [NA]), a new major source will be approved if it is equipped with pollution controls to assure the "lowest achievable emission rate (LAER)."

****Permit requirements for major sources locating in NA areas.

likely to be affected by the proposed project. Mitigation measures also may be imposed.

- The Fish and Wildlife Coordination Act requires the prevention of loss or damage to the wildlife resources in the area of the power plant as well as the development of a plan to develop and improve these resources, where possible.
- The Wild and Scenic Rivers Act, which created a National Wild and Scenic River system, requires that any proposed water resources project on a river section included in the system be disapproved if it would have a direct adverse effect on the values for which the river is so included.
- The National Historic Preservation Act requires any federal agency that licenses or funds projects that would affect structures and sites listed or eligible for listing in the National Register of Historic Places to take into account the effects of the proposed project on such structures and sites.

. . . legislative efforts to further consolidate the environmental reviews required by various agencies should be initiated.

A study performed by Envirosphere and funded by the Natural Resources Section of Edison Electric Institute's Environmental Activities Department compared several other environmental statutory review requirements with the reviews required by agencies' NEPA regulations in order to analyze EIS review requirements. The environmental review requirements of 22 federal environmental statutes and 2 executive orders that could have impacts on the licensing of major energy projects were compared to the NEPA procedures of 8 federal permitting agencies that may require a permit or license for the construction of a new major energy facility. For each agency, matrices were developed which horizontally listed the relevant sections of its NEPA implementing procedures for environmental review. The vertical axis of each matrix listed those sections of the federal acts that explicitly require private parties to perform some form of environmental review. Checks were placed on the matrix where the requirements of a statute section overlapped with a requirement of the agency's NEPA implementing procedures.

An example of one set of NEPA implementing regulations reviewed in the study were those of the Corps, shown in Table 1. The Corps' regulations prescribe the specific NEPA implementing procedures for preparing EISs. A specific section in the Corps' regulations require that the environmental review should incorporate the requirements of specific federal environmental laws. Many of the permitting or licensing sections of the Clean Air Act, the Clean Water Act, and the Endangered Species Act, for example, required the same type of reviews as those performed in an EIS. The overlap between these laws and the EIS requirements are illustrated below by the checks on the Corps' matrix for these laws. The matrices for the other federal agencies reflected similar results when their EIS requirements were compared to the same list of other statutory environmental review requirements. The matrices illustrate that the environmental reviews in EISs may be duplicative, particularly in regard to larger energy projects where similar environmental reviews under various federal statutes are more likely to be required.

Since duplication of environmental reviews exists as a result of various legislation, legislative efforts to further consolidate the environmental reviews required by various agencies should be initiated. In the interim, however, changes in regulatory procedures may be made to consolidate reviews. For example, one section of the CEQ NEPA regulations requires agencies to incorporate material into an EIS by reference when the effect will be a reduction in paperwork without impeding agency and public review of this action. If a review already has been undertaken, a summary of it may satisfy the EIS requirement.

Another method of actually reducing environmental reviews is the use of a "nationwide permit." The Corps has proposed revisions to the dredge and fill permitting process that would reduce regulatory overlap by not "triggering" the EIS process. The revisions would provide a "nationwide permit" for several kinds of dredged and fill material discharges, including discharges for outfall and associated intake structures (but not for loading and unloading facilities) where the effluent is permitted under a NPDES permit

and where the adverse effects of the structures are minimal.

These and, of course, other administrative efforts could have the potential to shorten the environmental licensing process for power plants. It is to be hoped that alerting the utility industry and the government will help to simplify the environmental review process and yet still maintain environmental goals.

Cancelled and Abandoned Plants: A Dilemma for Electric Utilities

Since 1973 there has been increased uncertainty regarding electric utilities' plans to build new power plants. These changes have occurred due to rapid increases in fuel prices and construction costs, high rates of inflation, lower than expected rates of load growth, and an uncertain regulatory climate. As a result, many utilities have had to modify their construction plans and cancel plants under construction; the plants were either too expensive to build or not needed immediately to meet load growth. These cancellations have created a difficult financial problem for the investor-owned electric utility industry: how best to recover the expenditures already made on the cancelled plants.

During the years 1974–1981, electric utilities removed over 100,000 MW of scheduled new generating capacity from their expansion programs. When construction on such projects began, companies relied on the most accurate, then-current projections of load growth and construction costs; the decisions to build the new power plants were prudent. Since then, however, numerous economic, political, and technical factors have reduced the rationale for continuing construction of the plants. Most of the plants that have been cancelled or deferred are baseload nuclear or coal-fired facilities intended to replace expensive and obsolete oil-fired plants. One effect of these cancellations is that the utilities will not be able to pass on to their customers fuel cost savings that these plants would have provided; also the nation will not get the benefit of reduced consumption of scarce fuels.

In some states a utility is not permitted to recover plant construction costs until the plant goes into service. For a plant that has been cancelled, construction costs can be recovered only through a rate filing with the regulatory commission. Generally, the procedure that is used normally to recover such costs is to amortize (i.e., spread) the costs over several years, so that the ratepayers will get only small increases in their bills over several years. Since the amount is not being repaid to the utility immediately, the amortization results in still further costs to the utility (i.e., the cost of money) which the company seeks to recoup. The mechanism to do this is to include the unamortized amount of the costs in the utilities' rate base, so that the utility can earn a return (interest) on this amount. Including the unamortized amount in the rate base financially benefits the utility by providing its investors and lenders a return on their investment.

The issue that repeatedly has created this regulatory confusion has been the method of distributing the burden of repaying such expenses between investors and ratepayers. . . .

Despite the obvious benefits for utilities in so accounting for the costs of cancelled and abandoned plants, this issue is controversial, and its resolution by state and federal regulatory commissions, legislatures, and courts has been uneven and unpredictable. To date, the majority of utilities which have cancelled plants have been permitted to recover their costs and to amortize their expenses over periods ranging from 2 to 15 years; but, in 4 cases, the utility was not permitted to recover these costs. Of those utilities permitted cost recovery, nearly half were permitted to earn a return on the unamortized balance. The issue that repeatedly has created this regulatory confusion has been the method of distributing the burden of repaying such expenses between investors and ratepayers, and in some cases the decision as to whether the ratepayer should pay for any costs of a cancelled or abandoned plant.

The most extreme position taken on this issue is that of the Ohio State Supreme Court. In a recent decision, the court held that Ohio law does not permit a utility to collect from ratepayers any expenses resulting from a cancelled or abandoned project. The decision rejected an Ohio Public Utility Commission (Ohio PUC) order that allowed the Cleveland Electric Illuminating Company to amortize over ten years its

Contributed by the staff of Edison Electric Institute

expenses from the cancelled Davis-Besse Nuclear Plant Units 2 and 3 as well as the Erie Nuclear Plant Units 1 and 2. The company had not asked to include the unamortized amount in its rate base and merely had sought to share equitably the burden of recouping its loss between its shareholders and its ratepayers. The court realized that its decision "will seriously disadvantage" Ohio utilities in the financial market and will make necessary an increased return on investment. To avoid such difficulties, the court suggested that the Ohio PUC, Cleveland Electric Illuminating Company, and other companies involved in the loss petition the state legislature to revise Ohio statutes.

This regulatory confusion is exemplified in the Tyrone Energy Park abandonment case.

The Ohio Supreme Court decision focuses on the difficulties created by disparate treatment of the issue. Utilities might be allowed a certain method of cost recovery by the Federal Energy Regulatory Commission (FERC) on one hand and an entirely different method by a state commission. Further complications arise, as in the Ohio case, when the courts and legislatures become involved. These problems are exacerbated when different state commissions order different solutions. This regulatory confusion is exemplified in the Tyrone Energy Park abandonment case.

This 1,100 MW project was developed by Northern States Power Company (NSP); its Wisconsin affiliate, Northern States Power—Wisconsin (NSP-W); and three other utilities. The Tyrone station was to have been built in Wisconsin and the electricity it generated would have been sold to customers in Wisconsin, Minnesota, North Dakota, and South Dakota. To recoup its abandonment expenses, NSP filed with FERC as well as with the Wisconsin and Minnesota state commissions. Each regulatory body ordered different treatment: FERC allowed amortization of the total loss over ten years; the Wisconsin commission allowed amortization over five years; but the Minnesota commission, holding that the abandoned project did not benefit Minnesota ratepayers, refused to allow any amortization, a position also taken by the North Dakota commission. The issue is complicated further by differences between commissions over the allocation of expenses among different states' ratepayers.

The Tyrone case is unlikely to be resolved in the near future; the courts have only just begun to rule on the commissions' decisions. But while the company awaits such resolution, the costs continue to mount. The Tyrone debt must be repaid and future investors as well as lenders must be persuaded to provide needed funds for capital.

Second Quarter Rate Actions

Based on the results of Edison Electric Institute's latest Quarterly Rate Action Survey, it is estimated that the returns of common equity allowed by state commissions during the second quarter of this year averaged 16.05 percent, up slightly from the 15.92 estimated for the previous quarter. However, the percent of the amounts requested that the commissions granted is estimated to be down to 59.2 from 64.7. Regulatory lag on rate actions is estimated to average 8.5 months for the second quarter and 8.3 months for the first quarter.

Other results of the Survey are shown in Table 1. A summary of selected data for the 12 months ended June 30, 1982 is given in Table 2.

Table 1. Status of Second Quarter Electric Rate Actions*

Type of Action	Number of Actions		Dollar Amounts ($000)	
	Increases	Decreases	Increases	Decreases
Pending as of 6/30/82				
Filed During Quarter[1]	62	1	2,393,246	14,272
Pending from Previous Quarters	126	1	7,859,568	6,951
Total Pending	188	2	10,252,814	21,223
Approved During Quarter[1]				
Non-Final[2]	11	0	703,025	0
Final	67	6	893,893	20,301
Total Approved	78	6	1,596,918	20,301
Withdrawn During Quarter	0	0	0	0
Denied During Quarter[3]	0	0	0	0
Cumulative Totals—First Two Quarters of 1982				
Filed	119[4]	1	6,918,420[4]	14,272
Approved	155	7	3,412,474	29,418

*Based on reports filed by 166 investor-owned electric utility companies.

Notes

[1] Approved changes which were filed during quarter are only counted in the approved category.

[2] Includes interim increases not subject to refund, increases under bond, and increases subject to refund.

[3] Only final denial of any increase in rates is reported as denied. When a utility is granted less of an increase in rates than it filed for, the remainder is not reported as denied.

[4] Revised from previously reported figures to reflect late-reported and utility-corrected information.

Table 2. Summary of Selected Data—12 Months Ended 6/30/82

Time Period	Increases Filed During Period		Total Increases Pending at End of Period		Increases Approved During Period	
	Number	Amt ($000)	Number	Amt ($000)	Number	Amt ($000)
Third Quarter 1981	56	3,285,862	201r	9,633,977r	77r	1,756,141r
Fourth Quarter 1981	61	2,841,220	186	8,387,635	76	2,571,241
First Quarter 1982	57r	4,525,174r	183r	9,994,476r	77	1,815,556
Second Quarter 1982	62	2,393,246	188	10,252,814	78	1,596,918
Twelve Months Ended 6/30/82	236	13,045,502	—	———	308	7,739,856

r = revised from previously reported data.

Nondestructive Evaluation Center

On a nine-acre site in Charlotte, N.C., the electric utility industry is making substantial strides toward improving the safety and reliability of the nation's nuclear power plants.

The advances are being made at the Nondestructive Evaluation (NDE) Center at University Research Park in Charlotte. The Center, dedicated in 1981, was established by the Electric Power Research Institute (EPRI) in response to the industry's need for a facility at which it can take new research technologies off the shelf, apply them to real-life situations, and evaluate the results, according to Dr. Gary Dau, senior program manager at EPRI.

At the NDE Center, inspection and maintenance problems in power plants are studied with . . . ultrasonics, x-rays, eddy currents, and other diagnostic tools.

At the NDE Center, inspection and maintenance problems in power plants are studied with the use of nondestructive evaluation techniques, which involve probing plants with ultrasonics, x-rays, eddy currents, and other diagnostic tools. Technicians using these tools are searching for flaws in welded joints that might affect the plant's integrity.

For example, a major advancement in nondestructive evaluation is the Boiling Water Reactor Owner's Group (BWROG) Pipe Remedy Application and Demonstration Program. The program is designed to improve nuclear power plant reliability by providing proven methods to correct and prevent intergranular stress corrosion cracking from occurring in stainless steel piping of boiling water reactors. The techniques are used particularly for large piping systems (10 to 28 inches in diameter), which are difficult to work with because they are located in congested areas of the plant.

The demonstration program has shown that the corrosion cracking can be remedied by removing the part of the pipe containing the defect and replacing it with a material proven to be immune. The existing material at the junction of the pipes is then protected by using a technique known as "heat sink welding." Practicing this technique before a power outage occurs should substantially reduce the time and cost of large pipe replacement.

Another significant technology demonstrated at the NDE Center is a miniature linear accelerator (MINAC). MINAC was developed to be used for radiography of thick section steel or other dense material such as heavy pump bodies, large valve bodies, and heavy wall, large diameter piping. It can be used at any installation that can accommodate a large radiation exclusion area.

In their checks for hidden structural flaws, nuclear plant component manufacturers depend on high-energy accelerators to achieve the radiation intensities needed to penetrate foot-thick steel sections. Unfortunately, these huge accelerators are permanently installed and not capable of in-service inspection.

In contrast, MINAC is portable and has the versatility and power of the large accelerator to meet in-service needs. In its present configuration, MINAC is five times smaller than the conventional accelerators used by component manufacturers.

MINAC is currently being used, adapted, and evaluated by NDE Center personnel. Some adaptation of either MINAC or its related equipment to the specific needs of particular plants will be necessary during each use because no two plants are identical. MINAC has been used by four utilities to date to perform difficult inspections and is scheduled for use in other utility inspections in 1983.

The Center also is doing extensive work to inspect nuclear plant steam turbines and to predict their lifetimes. Although turbine failures are rare, significant damage could result if failure were to occur. A typical turbine rotor may weigh as much as 150 tons. As a reminder of the importance of his work, NDE Center manager Frank Ammirato keeps in his office a section of the turbine from TVA's Gallatin Station which fractured in 1974 due to a large flaw in its forging.

To inspect the turbines, high frequency sound waves are introduced into the metal, and reflections of these waves caused by interior flaws are detected and recorded. If repairs are required, the ultrasonic test results give the locations of flaws that are to be re-

Contributed by the staff of Edison Electric Institute

moved. Using the results of such nondestructive examinations and their knowledge of turbine design and operation, utility engineers must evaluate rotors' fitness for service. In order to assist them, EPRI has made available a computerized rotor lifetime prediction program called SAFER (Stress and Fracture Evaluation of Rotors).

Eddy currents are being used to inspect the integrity of steam generator tubes in nuclear plants. Pressurized water reactors' steam generators are heat exchangers which contain thousands of tubes. Defects in the thin-walled tubes are detected using eddy currents induced in the tube by a coil introduced through the tube bore. Defects in the tube wall disturb the current flow and the disturbance is sensed by the coil. Signals from the coil are routed to a display for interpretation by an analyst who can make an assessment of tube wall integrity.

"This one-of-a-kind facility is dedicated to closing the gap between laboratory research and field application of new inspection techniques," said Dr. Dau. "Once a new system is successfully demonstrated and qualified, workshops for utility and commercial service personnel are held at the Center to train them in using these new techniques."

While all the work at the Center now involves nuclear power plants, Dr. Dau says that in the future NDE personnel will evaluate inspection techniques for all types of generating stations. Work at the 67,000 square-foot facility is managed for EPRI by the J. A. Jones Applied Research Co., a subsidiary of J. A. Jones Construction Co., headquartered in Charlotte.

"This one-of-a-kind facility is dedicated to closing the gap between laboratory research and field application of new inspection techniques."

Wide range of experts agrees...

AMERICA'S ECONOMIC FINANCIAL HEALTH OR

By Charles J. Cicchetti

Former Chairman, Wisconsin Public Service Commission

During the past ten years, I have watched the electric utilities go from blue-chip investments to companies beset with financial difficulties. As a nation we face disastrous deterioration of our industrial strength and our living standards —unless this trend is reversed.

The electric utility system is the core of this nation's industrial strength and social fabric. It is time that thoughtful people throughout the country realize the national stake in the system's health and strength. Procrastination will be more costly, and many good options will be lost. If political expedience and inertia continue to rule the day, the ratepayer and the nation will be worse off.

By Alvin L. Alm

Director, Energy Security Program, Kennedy School of Government, Harvard University

The investor-owned electric utility industry is in financial trouble. Some public utility commissions, reacting to public anger over rising electricity rates, have squeezed utility earnings and returns to investors so that capital improvements have been delayed or denied.

Restoring the financial integrity of investor-owned electric utilities is crucial if this nation is to have a strong economy and a healthy society. An industry that is financially strapped, heavily in debt and enervated from constant battles with state regulatory commissions is in no shape to meet urgent national needs.

By Maurice Fulton

Chairman of the Board, The Fantus Company

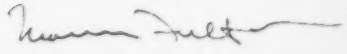
The ability of America's electric utilities to make the investments necessary today to assure adequate supplies tomorrow is critical to the industrial revitalization of the country. New generating facilities can require ten years or more to be brought on stream. In the meantime, existing facilities are becoming out of date and increasingly expensive to operate.

But utilities cannot invest in new generation, transmission and distribution facilities—or even adequately maintain existing facilities —if they cannot attract investment capital. To do that, they must be permitted to earn sufficient amounts to assure their financial health and provide returns competitive with other potential investments. In many cases, shortsighted regulatory policies are sapping the financial strength of utilities so that they ar having difficulty raising capital at reasonable cost.

Consequently, programs for nev capacity, conversion to cheaper, dependable fuel supplies and replacement of obsolete facilities have been postponed or abandoned

With alarming frequency, utilities are telling us that they canno economically handle the increase demand a major industrial develop ment represents today, much less provide assurance of adequate sup plies into the 21st century.

The eventual cost to the communities served by these utilities —in lost employment, erosion of ta base, stagnant economic activity— will far outweigh the cost of restoring America's electricity syster to financial health.



By Eugene M. Lerner

Professor of Finance, Northwestern University Graduate School of Management

Future costs and quality of service depend upon the ability of electric utilities to finance new facilities and equipment now. To attract the capital required, utilitie must be able to earn sufficient amounts to provide a fair return t investors after actual operating costs have been defrayed.

Unfortunately, the returns permitted by most state regulatory commissions today are below thos offered by competitive, relatively safer investments. Actual

FUTURE HINGES ON ELECTRIC UTILITIES

eturns are even lower. As a result, any utilities have had to cut ack efforts to increase efficiency, onvert to lower cost fuel, and evelop new generating technolgy. When they do undertake such rograms, they often must pay remium rates for funds.

Sooner or later, the consumer ust pay the higher financing costs hat financially weak utilities incur. n alternative is to delay necessary nprovements, which will mean till higher costs in the future and ossible deterioration of service.

As an important result of more vorable regulation, utility managements are able to make operating nd investment decisions based on ng-term public need, rather than n short-term financial exigencies.

y Sanford I. Weill

hairman, Shearson/American xpress Inc.

Business and industry are dependent upon adequate, reliable power t the lowest possible price. Without it, the companies in which our lients invest could not prosper.

Emerging industries could not row, and basic industries would isintegrate. Essential programs to ebuild the nation's industrial plant nd increase productivity would e doomed.

Electric utilities will have to pend about $340 billion in the remainder of this decade to increase the efficiency of existing facilities, reduce dependence on petroleum fuels and build the minimum capacity required to meet tomorrow's power needs.

At least half that capital will have to come from outside investors. For utilities, probably more than any other kind of business, that means being able to attract the savings of individuals.

By Robert A. Georgine

President, Building and Construction Trades Department, AFL-CIO

No one has a greater stake in the financial health of the nation's electric utility industry than Americans who work for a living.

Utilities must be financially strong in order to make the investment necessary to power the industrial revitalization the United States needs if we are to produce the jobs that are absolutely essential to bring about our immediate economic recovery and subsequent growth.

Industry strongly considers the availability and dependability of electricity in its decisions to locate new or to expand existing plants. Communities which cannot assure reliable, abundant power over the long term, therefore, will lose jobs and tax revenues. Indeed, we are already seeing some signs of this on a regional basis.

By Claire V. Hansen, C.F.A.

President and Chief Executive Officer, Duff and Phelps, Inc.

Utilities in states where reasonable rates are permitted have higher credit ratings. Therefore, they can raise funds at lower cost to the consumer for plant and equipment modernization, conversion to lower cost fuels, new technology development, transmission grid maintenance, and meeting basic local growth requirements. Denial of reasonable earnings will inevitably result in degradation of service —including possible power rationing and brownouts--and even greater escalation of costs to consumers over the long term.

When establishing allowable rates of return, regulators must balance their efforts to keep down immediate consumer costs against the even more important responsibility to assure adequate power supplies for the future.

This is one of a series of messages sponsored by the Edison Electric Institute, representing the investor-owned utilities that deliver 77% of the nation's electricity.

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